Benthic TMDL Development for South Run, Virginia

Submitted to

Virginia Department of Environmental Quality

Prepared by

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. South Run was included on Virginia's 2002 303(d) TMDL Priority List and Report (DEQ, 2002a, 2004b) because of violations of the General Standard (benthic impairment). The majority of the South Run watershed is located in Fauquier County, Virginia.

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Bioassessments of the benthic macroinvertebrate community of South Run were performed by DEQ using the EPA Rapid Bioassessment Protocols. The majority of the results of bioassessments indicated a moderately impaired benthic community at one monitoring station on the creek (Station 1ASOT001.65). Therefore, since the creek only partially supports the designated aquatic life use, the General Standard for the creek is being violated. As a result, the creek was included on the 303(d) list. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

The listed segment of South Run (VAN-A19R-04) is about 2.34 miles in length, beginning immediately downstream of Lake Brittle, and ending at the confluence of inundated waters of Lake Manassas. Station 1ASOT001.65 is located approximately 0.86 miles downstream from Lake Brittle.

Watershed Characterization and Environmental Monitoring

The South Run watershed is approximately 4,487 acres. Forested (34.7%), developed (31.1 %), and agriculture (34.1 %) lands represent land area. The watershed is part of the Piedmont ecoregion which comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. The majority of the soils in the watershed are comprised of the Catoctin-Myersville-Rock Outcrop (29.2 %), Braddock-Dyke (18.1 %), and Penn-Croton-Calverton (38.5 %). The soil associations consist of soils of hydrogroups B and C, and therefore have moderate to slow infiltration rates.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) that impacts the benthic community of South Run. Available monitoring data included biological assessments, water quality monitoring data, and Discharge Monitoring Reports (DMR) for permitted facilities in the watershed. Biological monitoring data from 1994 to 2000 and from 2004 to 2005 were analyzed. Instream water quality conditions were assessed primarily based on results from a diurnal dissolved oxygen monitoring study, field data collected during biological monitoring surveys, and toxicity testing. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the wastewater treatment facilities in the watershed.

Stressor Identification

The primary stressor identified for South Run was determined based on evaluations of candidate stressors that potentially could be impacting the stream. Based on the stressor identification analysis, the most probable stressor for the benthic community of South Run was identified as total phosphorus enrichment. Potential sources of total phosphorus in the watershed include agricultural runoff, urban stormwater runoff, point source dischargers, as well as Lake Brittle (a managed lake for game fish).

Improvement of the benthic invertebrate community in South Run is dependent upon reducing nonpoint source and point source total phosphorus loading to the stream. These measures should serve to improve benthic habitat and subsequently restore invertebrate populations in the stream. Therefore, a total phosphorus TMDL was developed for South Run.

Reference Watershed Approach

TMDL development requires the determination of an endpoints, or water quality goals or targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for total phosphorus. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for South Run.

The Popes Head Creek watershed was selected as the reference watershed for the South Run benthic TMDL development. Reduction of total phosphorus loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for South Run.

Total Phosphorus Loading Determination

Total phosphorus sources within the South Run watershed include both point and nonpoint sources. The only point source loading into the watershed is from an individual permitted discharge facility, Vint Hill Farms Wastewater Treatment Plant (WWTP). Nonpoint sources include total phosphorus in agricultural and urban runoff.

Total phosphorus loads were determined for both the reference and impaired watersheds in order to quantify the reductions necessary to achieve the designated aquatic life use for South Run. Total phosphorus loadings from land areas were determined using the Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1994 to 2004 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of South Run. Average annual total phosphorus loads were computed for each land source based on the 10 year simulation period. Point source loads were computed based on the facility's existing average flow and total phosphorus concentrations recorded in 2004 DMR data.

Under the reference watershed approach, the TMDL endpoint is based on total phosphorus loads for the reference watershed. Since the South Run reference watershed is smaller than the impaired watershed, reference watershed parameters were adjusted to reflect the size of the impaired watershed. Total phosphorus loads computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Total phosphorus TMDL allocations for South Run were based on the following equation.

TMDL = WLA +LA + MOS

Where:
TMDL= Total phosphorus Load of the Adjusted Reference Watershed
WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The wasteload allocation represents the total phosphorus load allocated to point sources. The load allocation represents the total phosphorus load allocated to nonpoint sources. A margin of safety is applied to account for uncertainty in methodologies and determination of total phosphorus loads. An explicit margin of safety of 10% was used for the South Run TMDL.

The evaluated South Run TMDL allocation scenarios considered phosphorus load reduction from point and nonpoint sources in the watershed. Wasteload allocation is applied to Vint Hill Farms WWTP, the only individual permitted facility located within the South Run watershed. The facility is planning to expand the WWTP and is in the process of relocating the discharge outfall out of South Run watershed. The Vint Hill Farms WWTP discharge effluent will be relocated to Kettle Run to accommodate the WWTP facility expansion and to protect Lake Manassas, a public drinking water supply source. Load allocation will be applied to the land based loads in the watershed, equal percent reduction from all land sources except forested lands. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions.

The four scenarios considered in the South Run TMDL development are presented in **Table E-1**. Scenarios 1-3 where used to derive scenario 4 which is the TMDL for South Run. Scenario 1 represents the existing phosphorus loading conditions where the point sources load was based on the average 2004 DMR data and the NPS load was calculated using the 10-year simulation results using GWLF model. In scenario 2, the point source load was calculated using the facility existing design flow and a permitted phosphorus concentration of 0.30 mg/l. Scenario 3 examines the point source relocation impact on the total phosphorus loading. Scenario 4 is the TMDL and is based on point source relocation but preserves 2% of the phosphorus load for the potential addition of point sources and to account future growth in the watershed. The TMDL for South Run is presented in **Table E-2**.

Table E-1: South Run TMDL Scenarios

Scenario		Point Source load	Nonpoint Source load
No.	**Description**		
1	Existing Condition	The load was calculated based on the average DMR data and current design flow.	The load was estimated based on simulation results from GWLF model.
2	Load at permitted limits	The load was calculated based on point source discharge effluent concentration of 0.3 mg/L and current design flow.	The load was estimated based on simulation results from GWLF model.
3	Facility relocation impact on loading	No load from the point source discharger. The outfall is relocated out of the watershed.	The load was estimated based on simulation results from GWLF model.
4	TMDL	Discharger outfall is relocated. However, 2% of the phosphorus load is reserved for potential future growth.	The load was estimated based on simulation results from GWLF model.

Table E-2: Total Phosphorus TMDL for South Run (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
0.562	0.496	0.010	0.056

Implementation

Currently the phosphorus load in South Run exceeds the TMDL endpoint by 32.7%. However, the only point source in the watershed, Vint Hill Farms WWTP, is in the process of relocating the outfall to Kettle Run Watershed. As a result, the phosphorus load in South Run will be reduced below the TMDL endpoint. No load reduction will be required from nonpoint sources in the watershed due to this relocation, since the TMDL endpoint is met and the average concentration in South Run was below the Chesapeake Bay Tributary Strategies average values for the Shenandoah and Rappahannock Rivers.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act’s Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

Public Participation

Watershed stakeholders had opportunities to provide input and to participate in the development of the TMDL. Three TAC meetings were held at the DEQ office in Woodbridge on March 1st, 2005, November 3rd, 2005, and March 1st, 2006. Two public meetings were held in the watershed, the first meeting was held on March 30th, 2005, and the second meeting was held on December 14th, 2005. The final public meeting was held on March 15th, 2006, to present and discuss the South Run Phosphorus TMDL.

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List of Acronyms

BMP	Best Management Practices
BRAC	Base Realignment and Closure
CECOM	Communications-Electronics Command
DCR	Department of Conservation and Recreation
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DGIF	Department of Game and Inland Fisheries
DMR	Discharge Monitoring Report
DMME	Department of Mines, Minerals, and Energy
DO	Dissolved Oxygen

EPA	Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
EPT	Epheroptera-Plecoptera-Tricoptera
GIS	Geographic Information System
GWLF	Generalized Watershed Loading Functions
LA	Load Allocation
LS	Length-slope
MFBI	Modified Family Biotic Index
MOS	Margin of Safety
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollution Discharge Elimination System
NVRC	Northern Virginia Regional Commission
OWML	Occoquan Watershed Monitoring Laboratory
PAHs	Polycylic Aromated Hydrocarbons
PCB	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
RBPII	Rapid Bioassessment Protocol II (needs to be spelled out, 3-6)
SCI	Stream Condition Index
STATSGO	State Soil Geographic
SWCB	State Water Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSI	Tissue-Screening Value
VADEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VHFS	Vint Hill Farms Station
VPDES	Virginia NPDES
UAA	Use Attainability Analysis
VDOT	Virginia Department of Transportation
WLA	Wasteload Allocation
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQMP	Water Quality Management Plan
WWTP	Wastewater Treatment Plant

1.0 Introduction

Total Maximum Daily Load (TMDL) development for biological impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow streams to attain their designated uses. The identification of the pollutant(s) or *stressor(s)*, responsible for the impaired biological communities, is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the waterbody to comply with Virginia's water quality standards. This report details the steps used to identify and characterize the stressor(s) responsible for biological impairments in South Run, Virginia. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. In the subsequent sections of this report, watershed and environmental monitoring data collected on South Run are presented and discussed. Stressors which may be impacting the creek are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic invertebrate communities in the creek are identified. A TMDL will be developed for the stressor identified as the primary source of biological impairment in South Run.

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001a).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and implement a more effective TMDL process. DEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. DEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA, passed by the Virginia General Assembly in 1997), and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (DEQ, 2006).

As required by the Clean Water Act and WQMIRA, DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (DEQ, 2002a). DEQ also solicits participation and comments from watershed stakeholders and the public throughout the TMDL process. Once TMDLs have been developed and the public comment period has been completed, the TMDLs are submitted to EPA for approval (EPA, 1999).

1.2 Impairment Listing

South Run was initially listed on Virginia's 1998 Section 303(d) List of Impaired Waters and was subsequently included on Virginia's 2002 Section 303(d) List of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2002a, 2004a, 2004b) because of violations of General Standard (benthic impairment). South Run was also listed on the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report due to exceedances of the water quality standards for fecal coliform bacteria. This report addresses the benthic impairment; the bacteria impairment will be addressed in a separate TMDL report. Biological assessments conducted at DEQ monitoring station 1ASOT001.65, located at the intersection of South Run and Route 215, indicate an impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing.

South Run is located in the northern region of Virginia, and is a tributary of Broad Run in the Occoquan River drainage. The majority of the South Run watershed is located in Fauquier County, Virginia; South Run flows through Fauquier County and into Prince William County, Virginia prior to its confluence with Broad Run. The impaired benthic segment of South Run (VAN-A19R-04) is 2.34 miles in length, beginning immediately downstream of Lake Brittle, and ending at the confluence of inundated waters of Lake Manassas. **Figure 1-1** depicts the impaired segment of South Run, as well as the delineated watershed boundary.

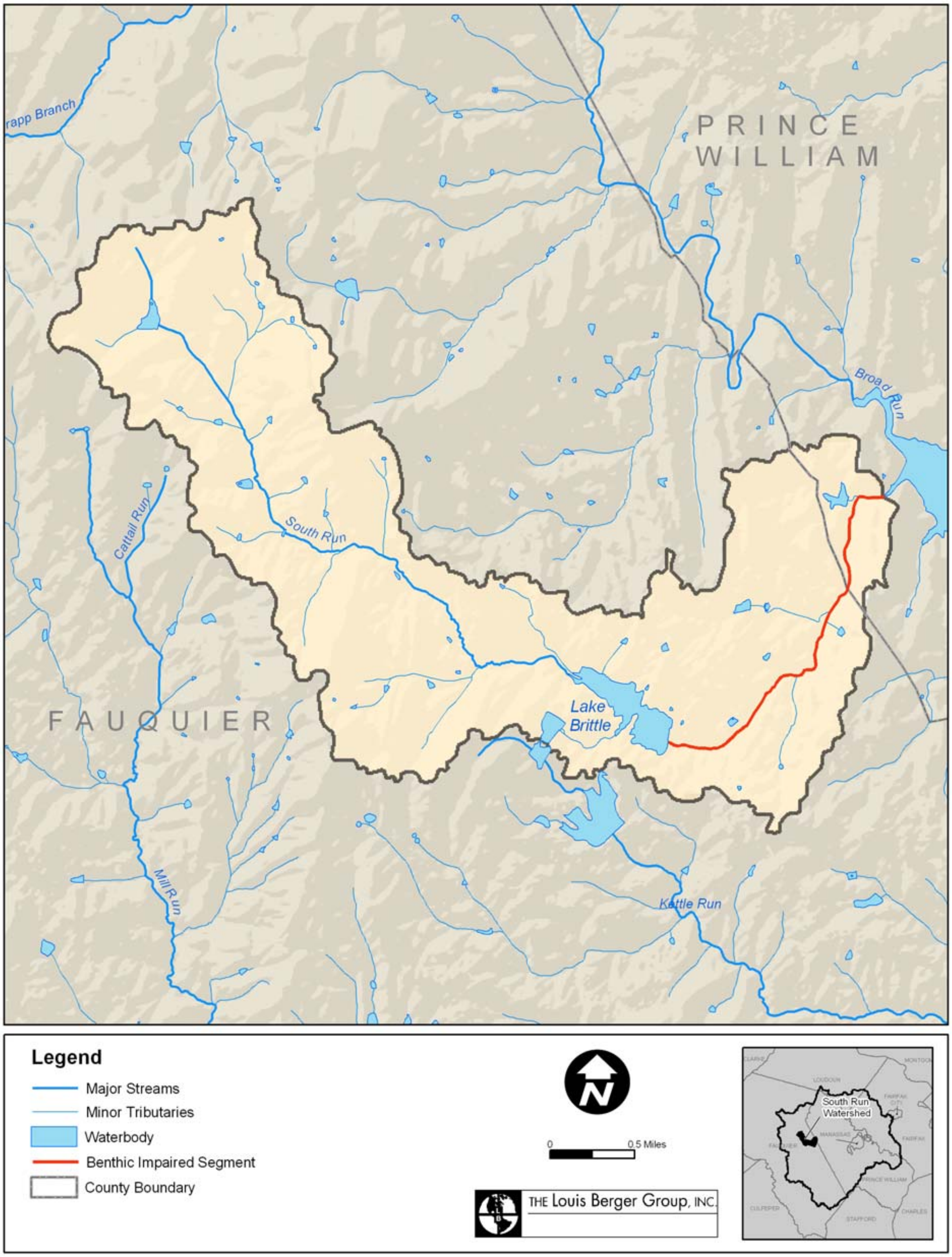

Figure 1-1: South Run Impaired Segment and Delineated Watershed

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *water quality standards* “means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.).”

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *“all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”*

The listed segment defined in Section 1.2 does not support the propagation and growth of aquatic life in South Run, based on the biological assessment surveys conducted on the creek.

1.3.2 Water Quality Criteria

The General Standard defined in Virginia Water Quality Standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standard states:

> *“All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or*

> *interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

The biological assessments conducted on South Run indicate that some pollutant(s) are interfering with attainment of the General Standard, as impaired invertebrate communities have been observed in the listed segment of the creek. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

2.0 Watershed Characterization

The physical conditions of South Run were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the listed segment of the creek. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. In particular, physical watershed features such as topography, soils types, and land use conditions were characterized. In addition, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the South Run watershed that may be contributing to the benthic impairment were analyzed using GIS coverages developed for the area. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

2.1.1 Watershed Location and Boundary

The majority of the South Run watershed is located in Fauquier County, Virginia; South Run flows through Fauquier County and into Prince William County prior to its confluence with Broad Run (**Figure 2-1**). The watershed is approximately 4,487 acres or 7.0 square miles.

2.1.2 Stream Network

The stream network for the South Run watershed was obtained from the USGS National Hydrography Dataset (NHD). The stream network and benthic impairment segment are presented in **Figure 2-1**.

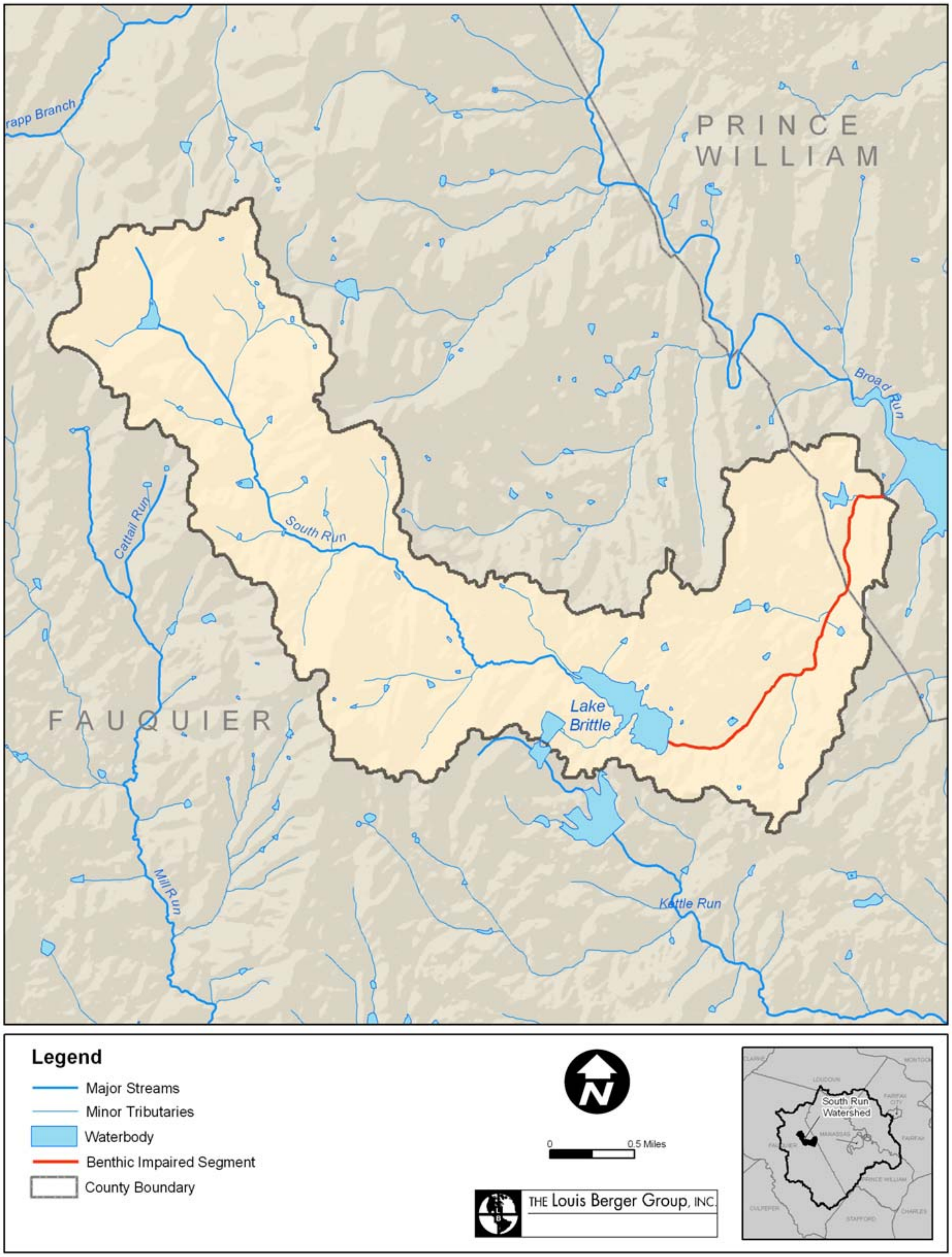

Figure 2-1: Stream Network for the South Run Watershed

2.1.3 Topography

A digital elevation model (DEM) was used to characterize topography in the watershed. DEM data obtained from BASINS show that elevation in the watershed ranges from approximately 258 to 771 feet above mean sea level, with an average elevation of 489 feet above mean sea level.

2.1.4 Soils

The South Run watershed soil characterization was based on the NRCS State Soil Geographic (STATSGO) Database for Virginia. There are six general soil associations present in the South Run watershed; Catoctin-Myersville-Rock Outcrop, Braddock-Dyke, Buckhall-Occoquan-Meadowville, Penn-Croton-Calverton, Airmont-Stumptown-Weverton, and Jackland-Waxpool-Catlett. The majority of soils in the watershed are comprised of the Penn-Croton-Calverton, Catoctin-Myersville-Rock Outcrop, and Braddock-Dyke soils associations. The distribution of soils in the South Run watershed, along with the hydrologic soil groups of each of the soils associations, is presented in **Table 2-1**.

Table 2-1: Soil Types in the South Run Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA006	Catoctin-Myersville-Rock Outcrop	29.2	B/C
VA012	Braddock-Dyke	18.1	B
VA013	Buckhall-Occoquan-Meadowville	3.2	B
VA015	Penn-Croton-Calverton	38.5	B/C
VA021	Airmont-Stumptown-Weverton	1.9	B/C
VA022	Jackland-Waxpool-Catlett	9.1	B/C/D

Source: State Soil Geographic (STATSGO) Database for Virginia

Hydrologic soil groups represent the different levels of soil infiltration capacity. Hydrologic soil group “A” designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the groundwater system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the groundwater, resulting in more rainfall delivered to surface waters in the form of runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

2.1.5 Land Use

The land use characterization for the South Run watershed was based on land cover data from both the Northern Virginia Regional Commission (NVRC) 2000 Land Use Dataset, and the 1992 USGS National Land Cover Data (NLCD). The NVRC dataset was the most recent available land use dataset, and was also utilized in order to be consistent with other ongoing modeling efforts within the Occoquan River watershed. However, the NVRC dataset does not specify forested or open (i.e., pasture) lands; therefore, the NLCD dataset was used to fill in the remaining areas. The distribution of land uses in the South Run watershed, by land area and percentage, is presented in **Table 2-3**. Agricultural lands (34.1%), forested lands (34.7%) and developed lands (31.1%) represent the dominant land use types in the watershed. **Figure 2-2** displays a map of the land uses within the watershed.

Table 2-3: South Run Watershed Land Use Distribution

General Land Use Category	Specific Land Use Type	Total Acres	Total Percent
Forested	Deciduous Forest	995.8	34.7
	Evergreen Forest	128.5	
	Mixed Forest	434.9	
Agriculture	Pasture/Hay/Livestock	1467.8	34.1
	Row Crop	64.3	
Developed	Low intensity residential	1252.8	31.1
	Commercial/Industrial	131.0	
	Medium/High Residential	2.5	
	Institutional	9.9	
	Urban/Recreational Grass	0.0	
Total		**4487.4**	**100**

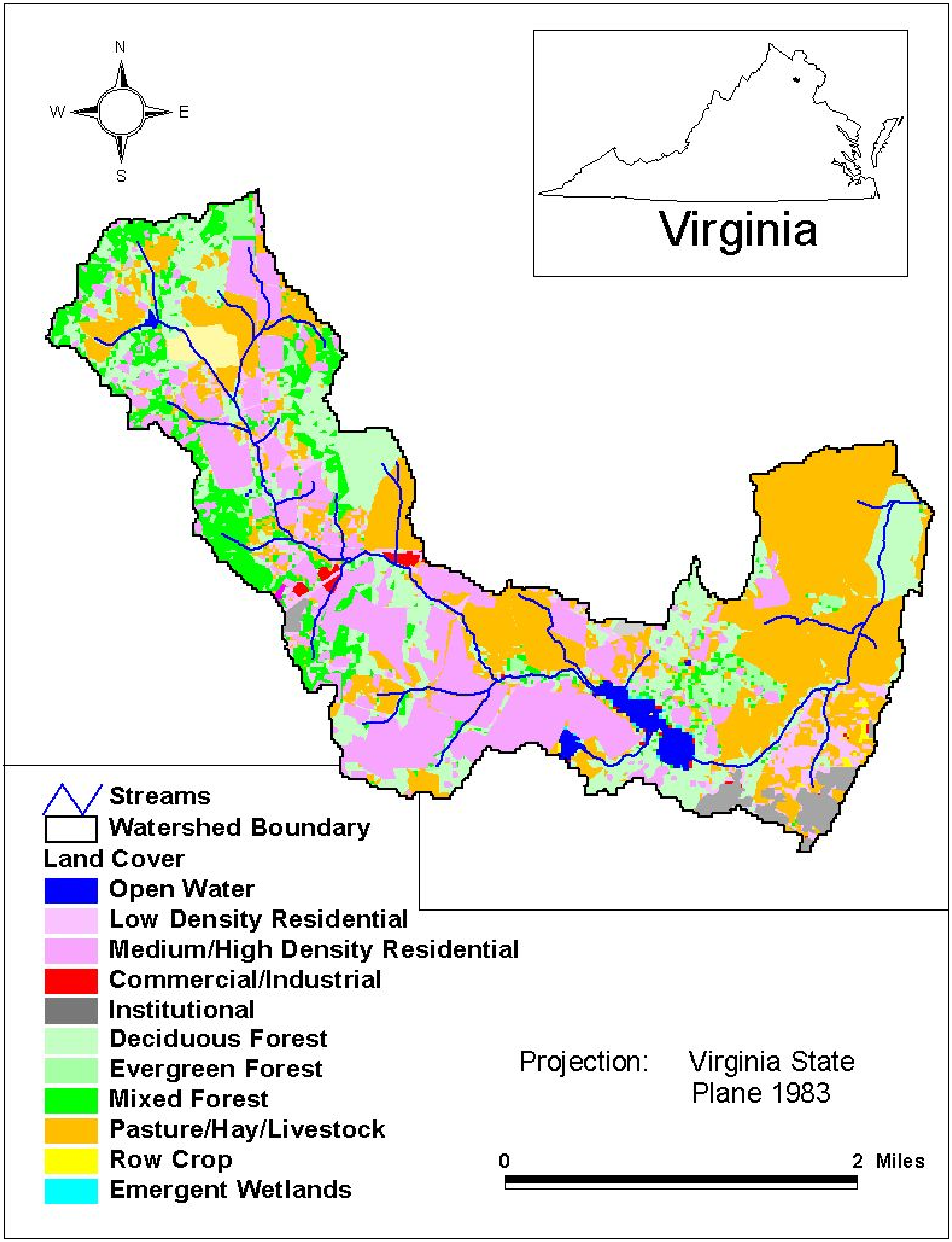

Figure 2-2: Land Use in the South Run Watershed

2.1.6 Ecoregion Classification

The South Run watershed is located in the Northern Piedmont ecoregion, USEPA Level III classification number 64 (Woods et al., 1999). The location of the South Run watershed within this ecoregion is presented in **Figure 2-3**. The Northern Piedmont ecoregion is a region of low rounded hills, irregular plains, and open valleys that serves as a transitional area between the low mountains to the north and west and the flat coastal plains to the east. Natural vegetation in the Northern Piedmont ecoregion is predominantly Appalachian oak forest, in contrast to the mostly oak-hickory-pine forests of the Piedmont ecoregion to the southwest.

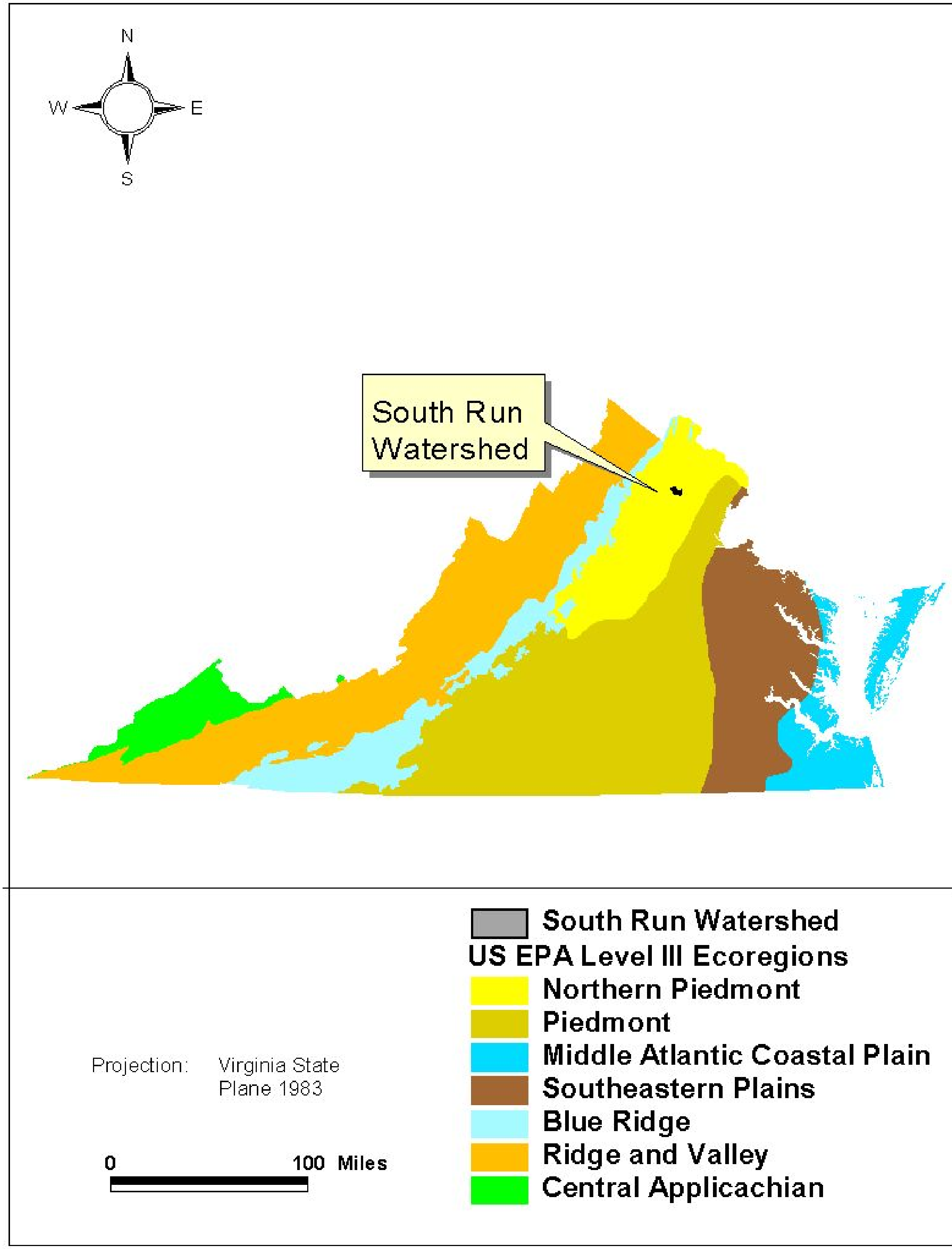

Figure 2-3: Virginia Level III Ecoregions

2.2 Permitted Discharge Facilities

There is one facility, the Vint Hill Farms WWTP which holds an active individual discharge permit in the South Run watershed. The permit number, type, permitted flow, receiving waterbody, and status of the Vint Hill facility is presented in **Table 2-4** and its location is presented in **Figure 2-4**. A total of 3 active general permits were issued in the South Run watershed; 1 permit issued to a domestic sewage treatment facility and based on DCR estimates 2 stormwater permits were issued to construction sites. Additional information on the domestic sewage permit is presented in **Table 2-5**.

Table 2-4: Individual Permitted Facility Discharging into the South Run Watershed

Permit Number	Facility Name	Facility Type	Design Flow (gpd)	Receiving Waterbody	Status
VA0020460	Vint Hill Farms WWTP	Municipal	270000	South Run	Active

Table 2-5: General Permits Issued in the South Run Watershed

Permit Number	Facility Name	Permit Type	Design Flow (gpd)	Receiving Waterbody	Status
VAG406134	Residence	Domestic Sewage	500	South Run, UT	Active

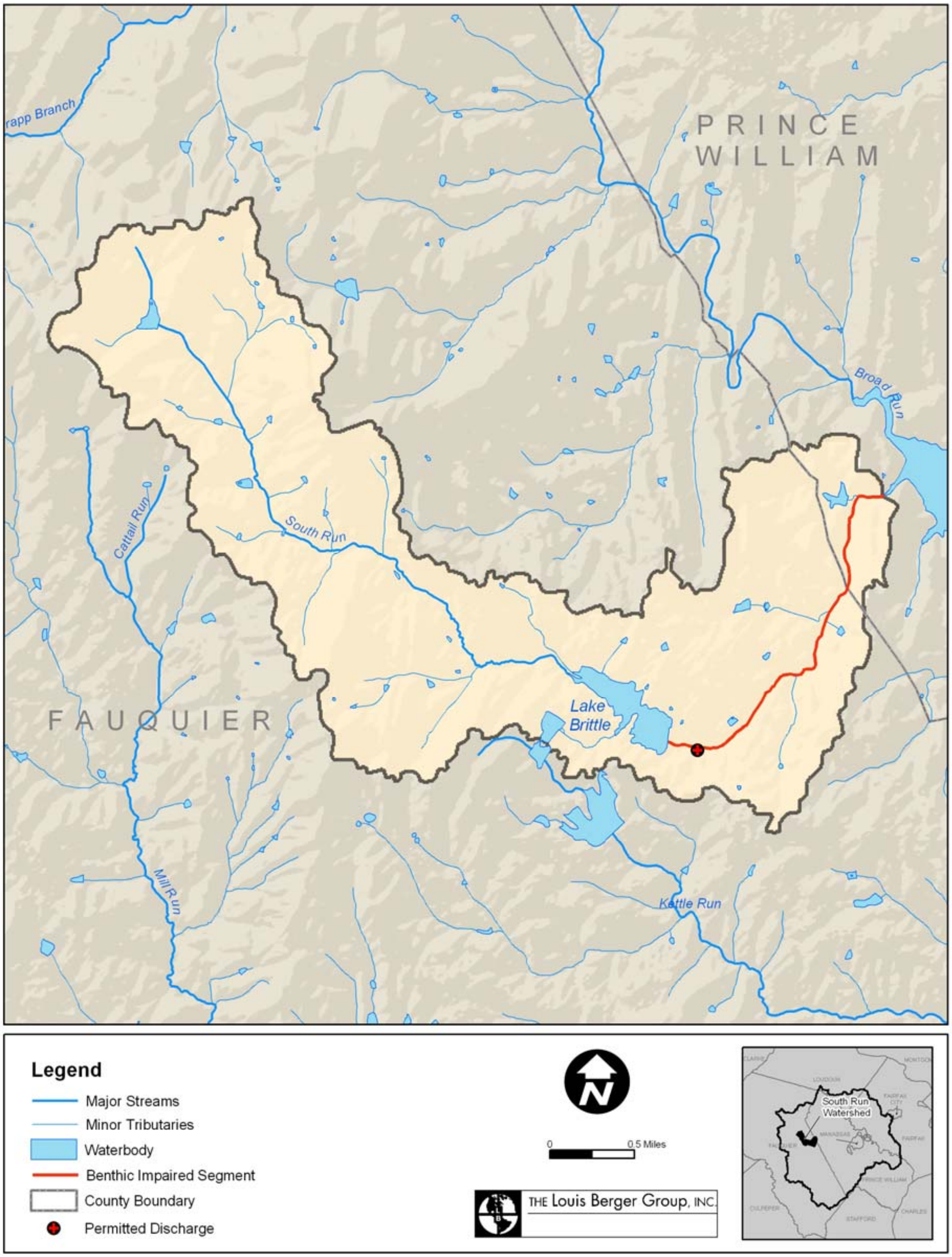

Figure 2-4: Location of Individual Permitted Facility Discharging into South Run

In addition to the individual and general permits presented above, two Municipal Separate Storm Sewer (MS4) permits have been issued to the City of Warrenton in Fauquier County and Virginia Department of Transportation (VDOT). **Table 2-6** lists the MS4 permit holder with the area covered by the individual MS4. The MS4 City area was calculated using the US Census Urban Areas and subtracting the acreages for the VDOT road areas. VDOT road areas were estimated using the roads length within the urban area and assuming a 25 foot-road-width. Combined, these MS4 permits cover approximately 30% of the South Run benthic impairment watershed. **Figure 2-5** presents the MS4 boundary of the City of Warrenton located within the South Run Benthic Watershed.

Table 2-6: MS4 Areas within the South Run Watershed

MS4 Permit	Acres
City of Warrenton	1,306
VDOT Roads	32
Total	1,338

Figure 2-5: The MS4 Area Located within the South Run Watershed

2.3 DEQ Monitoring Stations

DEQ has several monitoring stations on South Run which are used for biological and ambient water quality monitoring. A summary list of the DEQ monitoring stations located on South Run is presented in **Table 2-7**, and the locations of these stations are presented in **Figure 2-6**. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek.

Monitoring station 1ASOT001.44 contained the longest ambient water quality data record; recent ambient monitoring data have also been collected at station 1ASOT001.65. Biological monitoring data were collected at station 1ASOT001.65; South Run was classified as impaired based on the results of bioassessment surveys conducted at this station. A detailed discussion of the available environmental monitoring data is presented in Section 3.0.

Table 2-7: Summary of Monitoring Stations on South Run

Station ID	Station Type	Period Of Record
1ASOT001.44	Ambient Water Quality	1978-2001
1ASOT001.65	Ambient and Biological	1994-2004
1ASOT002.46	Ambient Water Quality	1989-1990

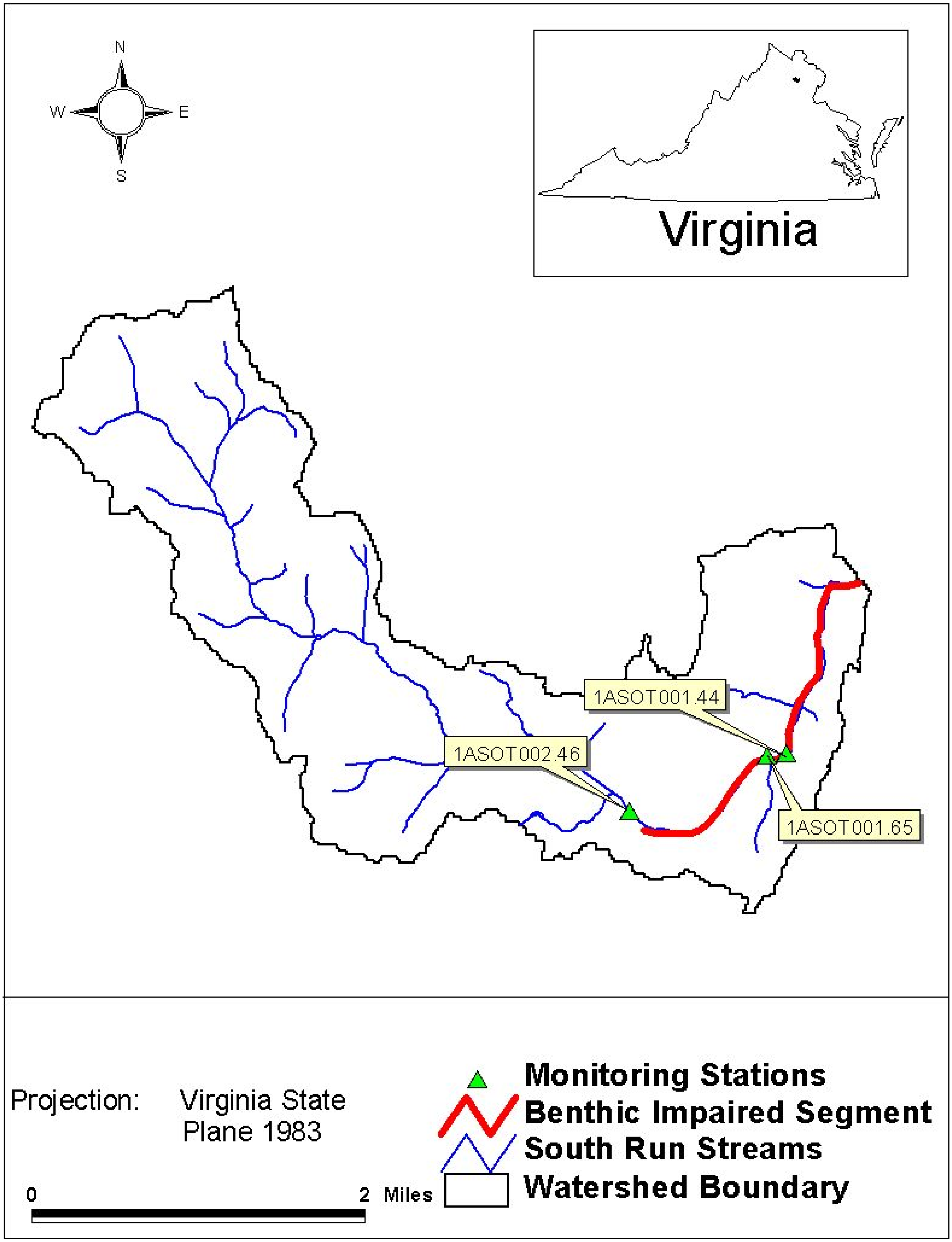

Figure 2-6: DEQ Monitoring Stations in the South Run Watershed

2.4 Overview of the South Run Watershed

Agricultural lands (34.1%), forested lands (34.7%) and developed lands (31.1%) represent the dominant land uses in the South Run watershed. There is one facility holding an active individual permit in the watershed, and three facilities holding active general permits in the watershed. Biological monitoring has been conducted by DEQ at station 1ASOT001.65 on the biologically impaired segment of South Run, and DEQ has collected ambient water quality data at three stations in the watershed. The land use and the locations of the facilities and monitoring stations in the watershed are shown in the summary map presented in **Figure 2-7**.

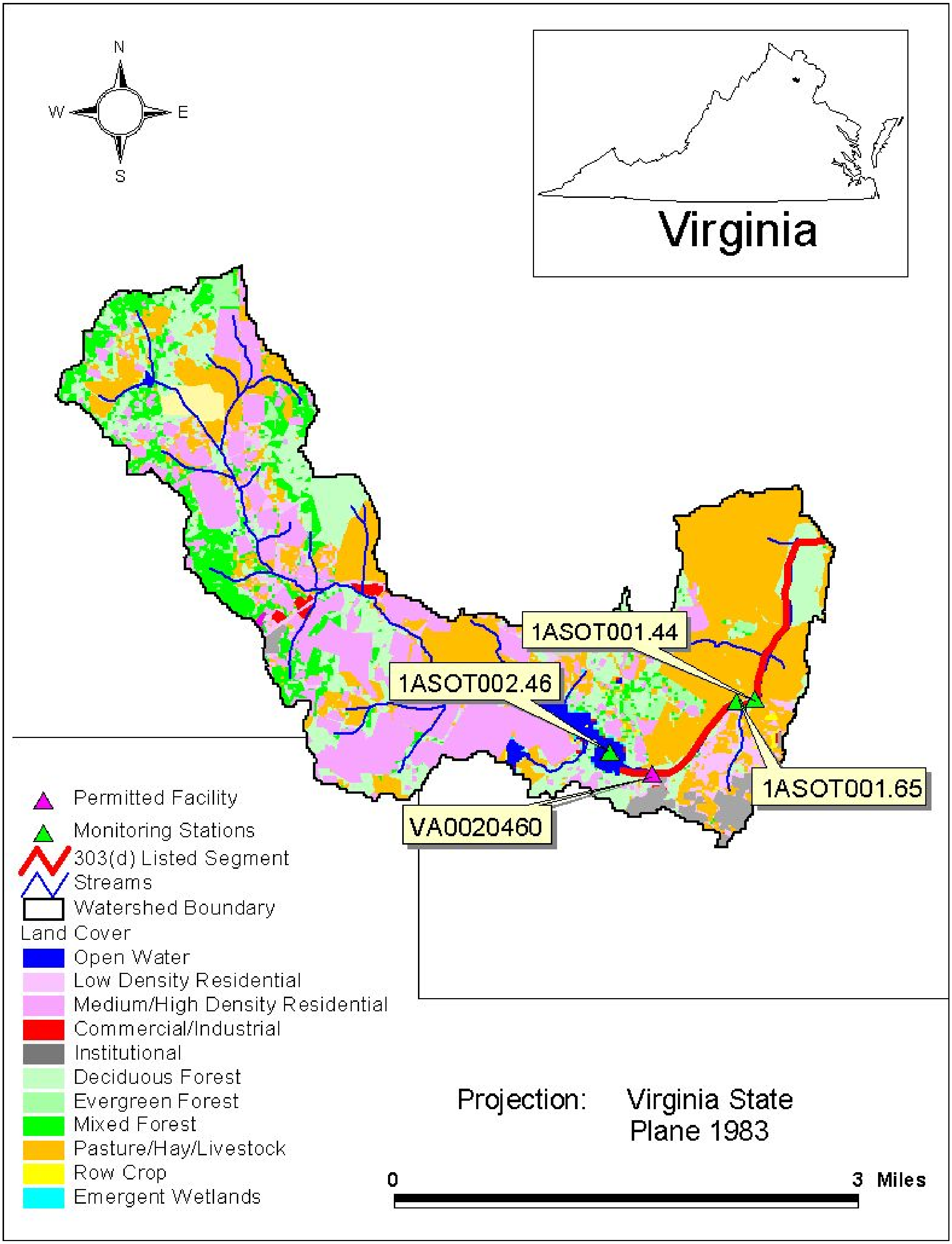

Figure 2-7: Overview of the South Run Watershed

3.0 Environmental Monitoring

Environmental monitoring efforts in the South Run watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, and toxicity testing. Monitoring efforts have been conducted by the Virginia Department of Environmental Quality (VADEQ) and the Occoquan Watershed Monitoring Lab (OWML). **Figure 3-1** plots the location of all monitoring locations in the South Run watershed used for this analysis.

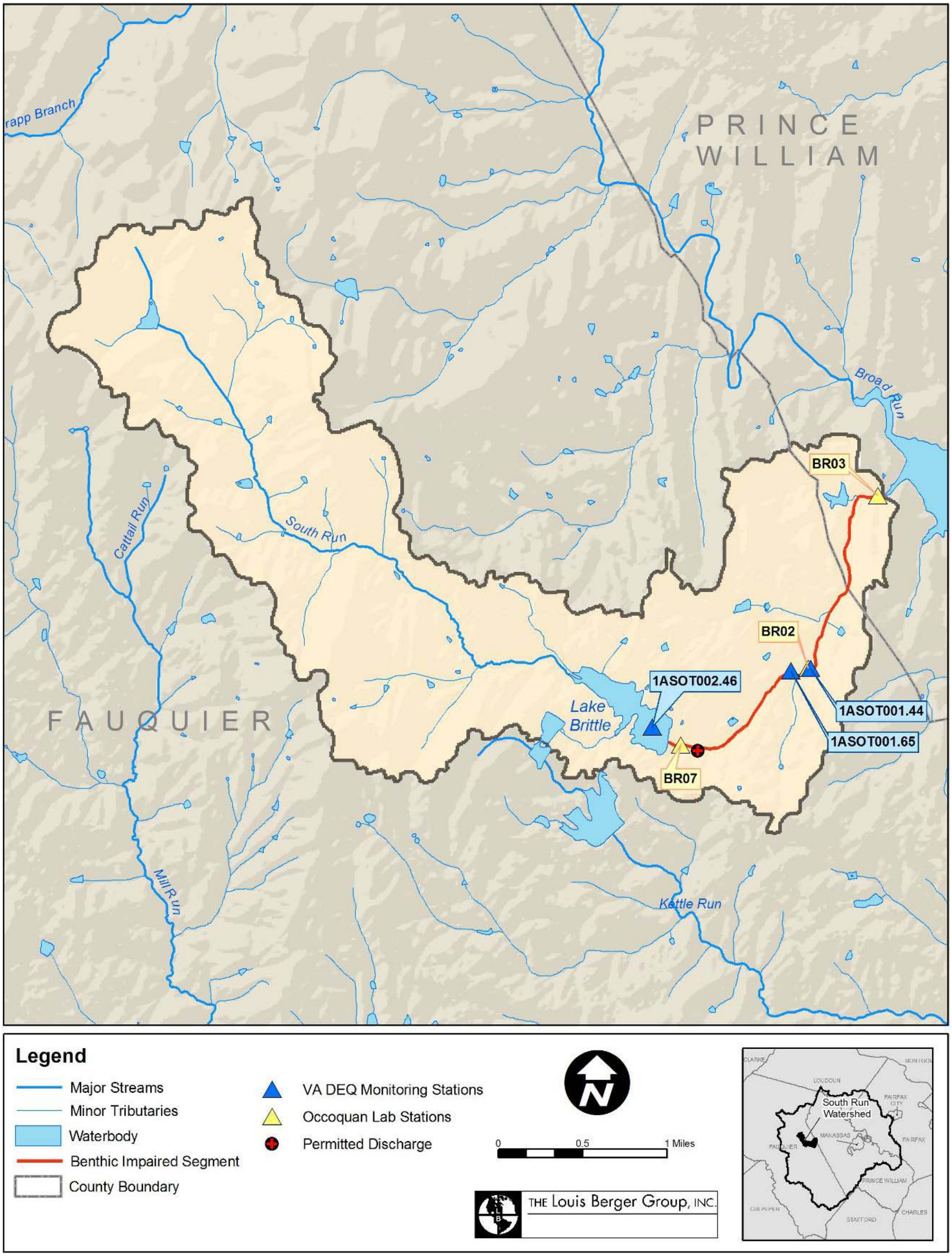

Figure 3-1: Monitoring Locations in the South Run Watershed

3.1 Virginia Department of Environmental Quality Data

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is impacting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor impacting the biologically impaired segment of South Run. Analyzed data included available biological and water quality monitoring data, Discharge Monitoring Reports (DMR) from the permitted facility, and results from recent DEQ instream toxicity studies conducted on South Run. The collection period, content, and monitored sites for these data are summarized in **Table 3-1**. The locations of permitted discharge facility and monitoring stations are presented in **Figure 3-1**.

Table 3-1: Inventory of Environmental Monitoring Data for South Run

Data Type	Collection Period	Monitoring Stations			Vint Hill Farms WWTP
		1ASOT001.44	1ASOT001.65	1ASOT002.46	
DEQ Biological Monitoring	1994-2005		X		
DEQ Ambient Water Quality Monitoring	1978-2005	X	X	X	
DEQ Field Water Quality Monitoring	1994-2005		X		
DEQ Toxicity Study	April 2004, May 2005		X		
Discharge Monitoring Reports (DMR)	1999- 2005				X

3.1.1 Biological Monitoring Data

The impaired segment of South Run was included on Virginia's 1998 Section 303(d) List of Impaired Waters and was subsequently included on Virginia's 2002 Section 303(d) List of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report based on biomonitoring results obtained between 1994 and 2004.

RBPII

A modified version of the EPA Rapid Bioassessment Protocols II (RBPII) was used to assess the biological condition of the stream's benthic invertebrate communities. Candidate RBPII metrics, as specified in EPA's *Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers* (Barbour et al., 1999), are presented in **Table 3-2**. RBPII assessment ratings for the biomonitoring surveys conducted on South Run are presented in **Table 3-3**.

Virginia DEQ bioassessments follow a paired reference approach using upstream stations located in the same watershed. The DEQ protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures (**Table 3-2**).

DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on South Run contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of each survey

Table 3-2: Candidate RBPII Metrics Specified in Barbour et al. (1999)

Category	Metric	Definition	Expected Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

Table 3-3: RBPII Assessment Ratings for South Run Biomonitoring Surveys

Station	Time Period	Assessment Rating
1ASOT001.65	Spring 1994	Moderate Impairment
	Fall 1994	Moderate Impairment
	Spring 1995	Moderate Impairment
	Fall 1995	Moderate Impairment
	Spring 1996	Moderate Impairment
	Fall 1996	Moderate Impairment
	Spring 1997	Moderate Impairment
	Fall 1997	Moderate Impairment
	Spring 1998	Moderate Impairment
	Spring 1999	Slight Impairment
	Fall 1999	Slight Impairment
	Spring 2000	Slight Impairment
	Fall 2000	Moderate Impairment
	Spring 2004	Slight Impairment
	Fall 2004	Slight Impairment
	Spring 2005	Moderate Impairment

Biomonitoring surveys were conducted biannually at 1ASOT001.65 from 1994 to 2000 and again from 2004 to 2005. Out of the sixteen samples taken at this station, eleven were rated as moderately impaired and five were rated as slightly impaired. Three RBPII metrics consistently showed scores that were lower than those observed at the reference site. The first two, EPT to Chrionomidae abundance ratios (which compares the total number of mayflies, stoneflies, and most caddisflies which are mostly sensitive to pollution, to the number of midges a predominantly tolerant family) and the EPT index (the total number of distinct taxa within the EPT groups) estimate the relative abundance of sensitive species present in the community and are therefore general indicators of water quality conditions. Scores for the third metric, the MFBI (Modified Family Biotic Index), were frequently observed above 4.5, which may indicate organic pollution is affecting the benthic community.

SCI Scores

Using the data collected during biomonitoring surveys, biological assessment scores were calculated using the Virginia Stream Condition Index (SCI) currently being developed by DEQ. The SCI is a regionally-calibrated index comprised of eight metrics that are listed in **Table 3-4**. The metrics used in calculation of an SCI score are similar to the metrics used in RBPII assessments. However, unlike RBPII, the reference condition of the SCI is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 61.3 has been proposed for assessing results obtained with the SCI. Streams that score greater than 61.3 are considered to be non-impaired, whereas streams that score less than 61.3 are considered impaired.

Calculated SCI scores for the biomonitoring station 1ASOT001.65, located on South Run, are presented in **Table 3-5**. SCI scores calculated for station 1ASOT001.65 were, on average, below the proposed impairment cutoff score of 61.3; therefore, the station is considered to be impaired. Station 1ACAX004.57, located on Catoctin Creek, served as the reference station for the South Run biological assessment from 1994 to 2000. However, this monitoring station was discontinued as a reference site after 2000 due to a decline in the observed benthic community at this location. Station 1AGOO022.44, located on Goose Creek, served as the reference station for the biological assessments conducted on South Run in 2004. Both of the reference stations had average SCI scores above the proposed impairment cutoff score.

Table 3-4: Metrics Used to Calculate the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Table 3-5: Virginia SCI Scores for South Run

Collection Period	SCI Score		
	1ASOT001.65	1ACAX004.57[1]	1AGOO022.44[2]
Spring 1994	Not available	-	-
Fall 1994	47.8	69.6	-
Spring 1995	56.8	72.4	-
Fall 1995	58.5	65.1	-
Spring 1996	40.5	66.4	-
Fall 1996	56.8	62.4	-
Spring 1997	60.2	69.7	-
Fall 1997	61.9	74.8	-
Spring 1998	65.7	73.6	-
Fall 1998	63.6	68.7	-
Spring 1999	58.5	72.5	-
Fall 1999	60.6	70.5	-
Spring 2000	63.7	70.5	-
Fall 2000	58.7	68.0	-
Spring 2004	44.4	-	67.6
Fall 2004	62.7	-	62.6
Spring 2005	42.2		
Average	**56.4**	**69.5**	**65.1**

1: Monitoring station 1ACAX004.57 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.2 Habitat Assessment Scores

A suite of habitat variables were visually inspected at station 1ASOT001.65 as part of the biological assessments conducted on South Run. Habitat parameters that were examined include channel alteration, sediment deposition, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Habitat assessment scores for the South Run biomonitoring station, as well as the reference stations, are presented in **Table 3-6**.

Overall habitat assessment scores were similar between impaired station 1ASOT001.65 and the reference stations. Individual habitat parameters were also generally similar between the impaired and reference stations, with the exception of the channel flow and velocity regime parameters, for which the reference stations on average scored higher than the impaired station.

Table 3-6: Habitat Scores for Reference and Impaired Stations

Station ID	Date	Total Habitat Score	Channel Alteration	Bank Stability	Bank Vegetative Protection	Substrate Embeddedness	Channel Flow	Riffles	Riparian Zone	Sediment Deposition	Velocity Regime
1ASOT001.65	Fall 1994	160	16	17	18	17	14	18	15	16	12
	Spring 1995	176	18	19	19	17	17	18	20	16	14
	Fall 1995	167	19	18	20	18	9	18	18	18	11
	Spring 1996	174	18	19	19	18	15	18	18	17	16
	Fall 1996	183	19	20	20	17	18	18	18	18	17
	Spring 1997	181	18	19	19	18	17	19	18	18	17
	Fall 1997	178	19	20	20	18	15	18	18	17	15
	Fall 1998	175	17	19	20	18	16	18	18	17	14
	Spring 1998	154	18	19	19	18	8	11	18	17	9
	Fall 1999	170	18	18	18	17	16	18	18	16	15
	Spring 1999	183	19	20	20	18	18	19	19	18	16
	Fall 2000	178	20	18	18	17	19	19	16	17	18
	Spring 2000	169	17	20	20	16	14	18	18	17	12
	Fall 2004	185	20	20	20	17	19	19	19	18	15
	Spring 2005	161	20	18	18	15	14	19	17	14	13
	AVG.	**172.9**	**18.4**	**18.9**	**19.2**	**17.3**	**15.3**	**17.9**	**17.9**	**16.9**	**14.3**
1ACAX004.57	Fall 1994	168	18	16	16	18	17	16	16	16	17
	Spring 1995	179	19	18	18	17	18	18	19	17	17
	Fall 1995	180	19	19	19	17	18	18	17	17	18
	Spring 1996	184	19	19	18	18	19	19	18	18	18
	Fall 1996	178	18	18	19	18	18	17	19	16	17
	Spring 1997	180	19	17	17	18	19	18	17	18	19
	Fall 1997	177	19	18	18	17	18	17	17	17	17
	Fall 1998	170	17	17	17	16	18	17	17	16	18
	Spring 1999	176	18	17	18	19	18	17	17	18	16
	Fall 1999	179	18	18	18	18	19	18	17	17	18
	Spring 2000	163	18	17	17	14	19	17	16	10	18
	Fall 2000	164	18	15	17	15	19	16	15	14	18
	Fall 2004	165	18	14	16	17	18	17	16	16	16
	AVG.	**174.1**	**18.3**	**17.2**	**17.5**	**17.1**	**18.3**	**17.3**	**17.0**	**16.2**	**17.5**
1AGOO022.44	Spring 2004	174	19	17	19	16	18	16	19	16	17
	Fall 2004	176	20	18	18	16	18	16	19	15	19
	AVG.	**19.5**	**17.5**	**18.5**	**16.0**	**18.0**	**16.0**	**19.0**	**15.5**	**18.0**	**19.5**

1: Monitoring station 1ACAX004.57 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.3 Water Quality Monitoring

There are three DEQ ambient water quality monitoring stations located in the South Run watershed. Information on each ambient monitoring station is summarized in **Table 3-7**. Monitoring station 1ASOT001.44 represents the largest sources of water quality data available in the watershed.

Table 3-7: Ambient Water Quality Monitoring Stations Located on South Run

Station Id	Station Location	Period of Record	River Mile	No. Sampling events
1ASOT001.44	Intersection with Route 215	1978-2001	1.44	214
1ASOT001.65	Intersection with Route 652	2003-2005	1.65	17
1ASOT002.46	Off Route 793, near Vint Hill	1989-1990	2.46	12

3.1.4 Instream Water Quality Data

Instream water quality data collected on South Run from 1990 to 2005 are presented in **Figures 3-2** to **3-12**. South Run is classified as a Class III waterbody (Nontidal Waters), as defined in Virginia Water Quality Standards (9 VAC 25-260-50). Thus, water quality parameters in the impaired segment must meet the Class III standards (**Table 3-8**).

Table 3-8: Virginia Water Quality Standards for South Run

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Average		
III	Nontidal Waters	4.0	5.0	6.0-9.0	32

Instream water quality data collected on South Run at stations 1ASOT001.65 and 1ASOT001.44 are presented in **Figures 3-2** to **3-12**. The following is a bulleted summary of the monitoring data:

- Field dissolved oxygen and temperature values have been in compliance with numeric criteria for Class III waters (**Figures 3-2** and **3-4**).
- pH values were also within the acceptable range for the majority of the period of record (**Figure 3-6**). However, at Station 1SOT001.44 a few exceedences of the minimum standard were recorded, and at Station 1SOT001.65 one exceedence of the maximum standard was recorded.
- Biochemical oxygen demand concentrations at the station were low (**Figure 3-7**).
- Total suspended solids concentrations were generally low, but were elevated during some sampling events (**Figure 3-8**).
- Nitrate concentrations were elevated in the early 1990's, but have been consistently below 2 mg/L since the mid 1990's (**Figure 3-9**).
- Nitrogen concentrations in forms of NH_3+NH_4-N were generally low across monitoring stations and sampling events (**Figures 3-10**).
- Historically, the total phosphorus concentrations were low, however, since 2003 concentrations substantially increased (**Figures 3-11**).
- Several violations of the Virginia fecal coliform instantaneous standard occurred at monitoring station 1ASOT001.44 (**Figure 3-12**); a bacteria TMDL is currently being developed for South Run and will be presented in a separate report.

Note: Date ranges in the following graphs are intentionally held constant for all graphs (excluding diurnal DO) to allow for vertical comparison between measured parameters. In those instances where no data is shown for a particular time period, no measurements of the parameter were taken allowing for visual identification of temporal data gaps.

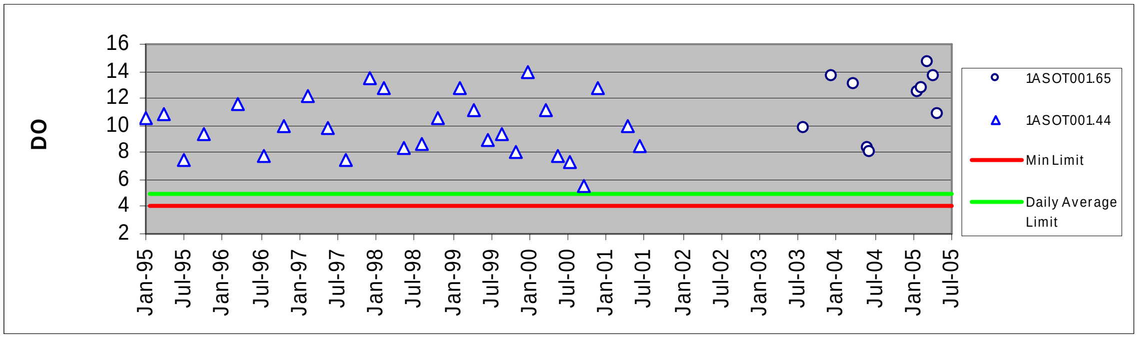

Figure 3-2: South Run Field Dissolved Oxygen Concentrations

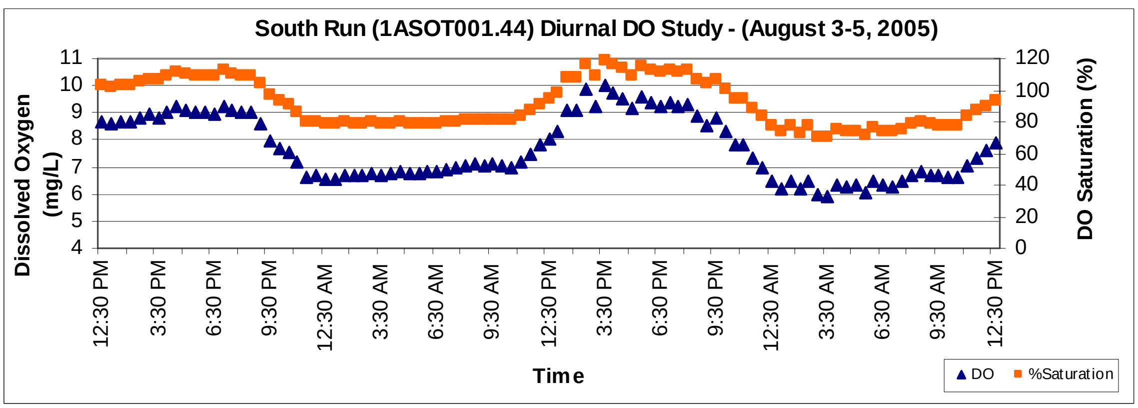

Figure 3-3: South Run Diurnal DO Concentrations

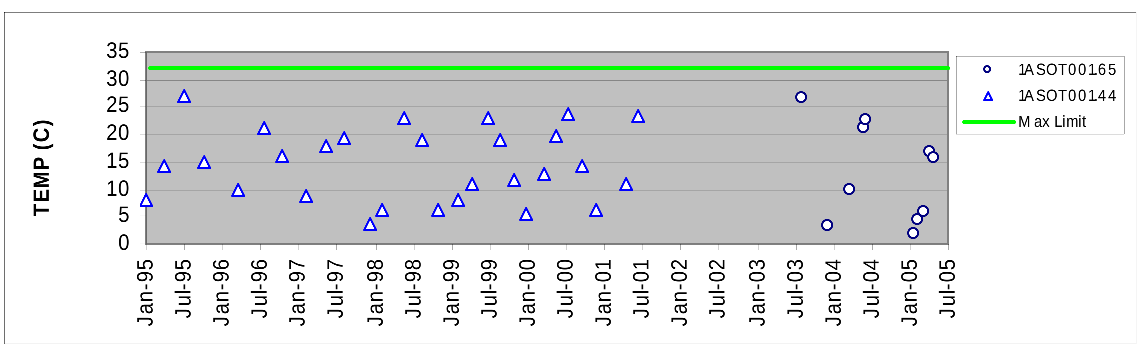

Figure 3-4: **South Run Field Temperature Data**

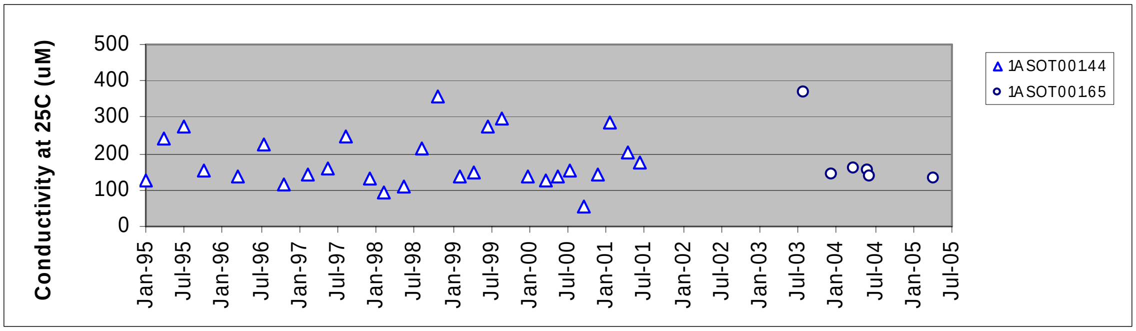

Figure 3-5: South Run Conductivity Data

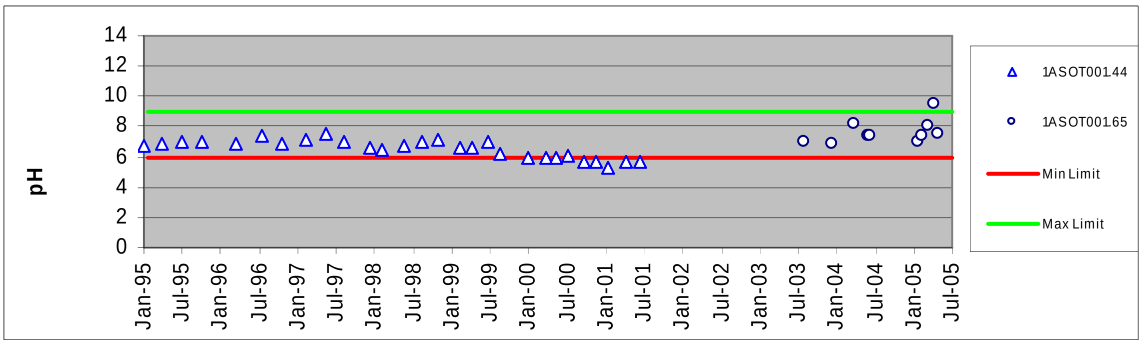

Figure 3-6: South Run pH Data

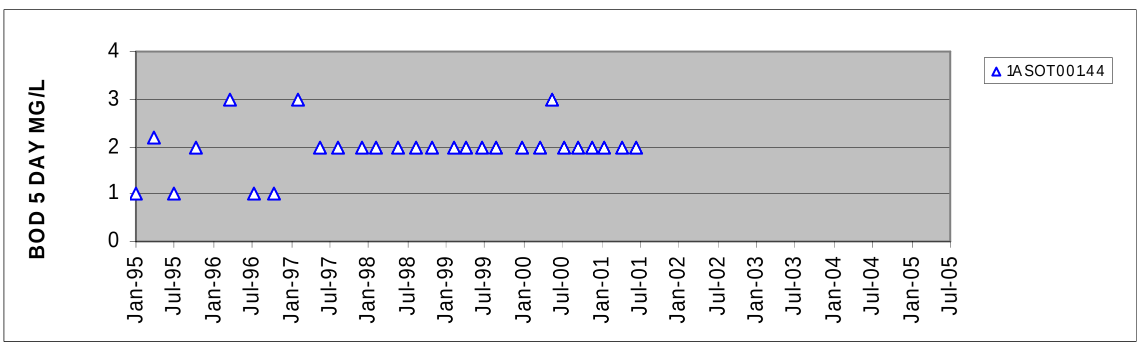

Figure 3-7: South Run Biochemical Oxygen Demand Concentrations

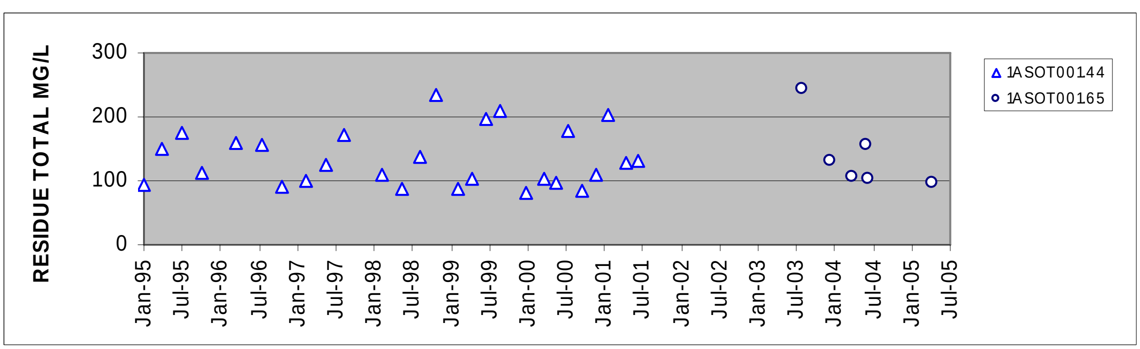

Figure 3-8: South Run Total Suspended Solids Concentrations

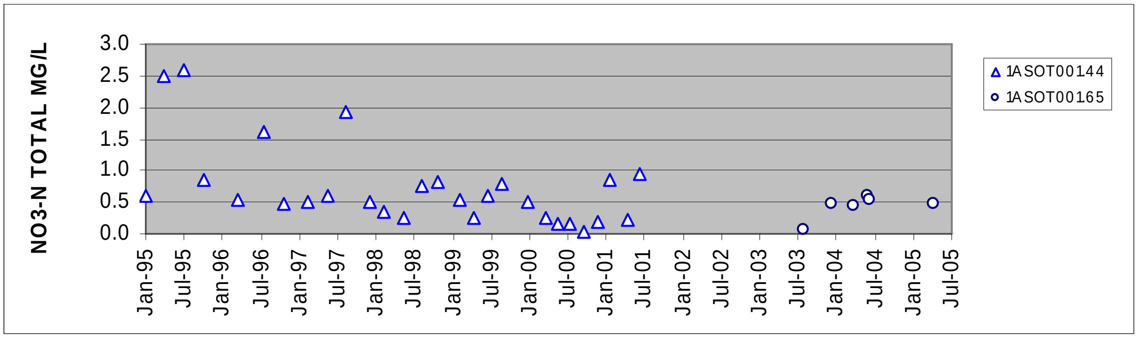

Figure 3-9: South Run Nitrate Concentrations

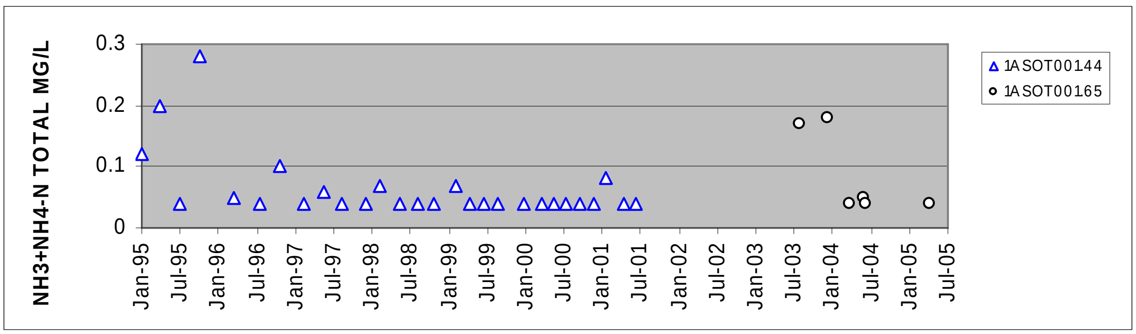

Figure 3-10: South Run NH3+NH4-N Concentrations

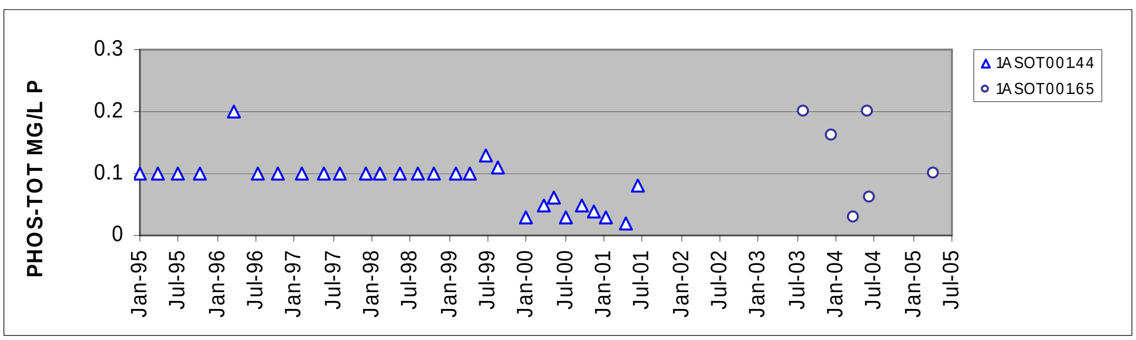

Figure 3-11: South Run Total Phosphorus Concentrations

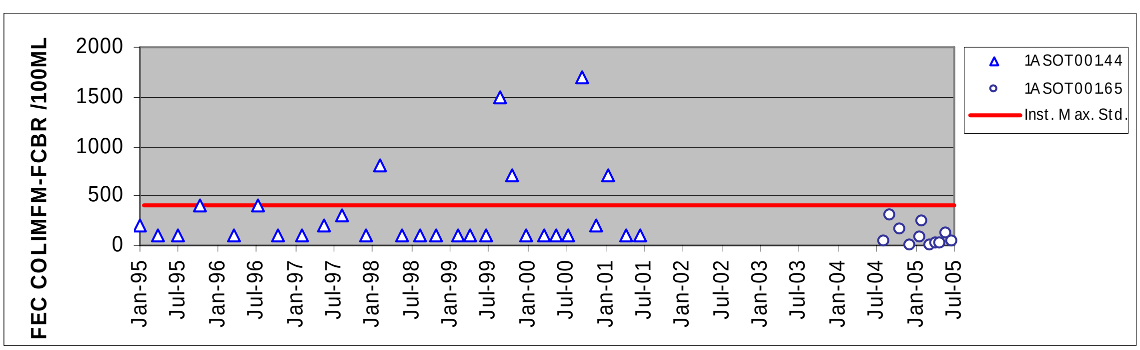

Figure 3-12: South Run Fecal Coliform Concentrations

3.1.5 Metals Data

Both dissolved (water column) and sediment metals parameters were examined in South Run, including arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. All available dissolved (water column) metals data collected in South Run were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards. No monitored metals parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Additionally, although there are currently no water quality standards established for sediment metals, the 2006 DEQ assessment guidance memorandum (DEQ, 2006) establishes consensus based sediment screening values for use in determining aquatic life use support. The sediment metals data collected on South Run were analyzed to determine whether they complied with the consensus based screening values. The consensus based Probable Effects Concentration (PEC) sediment screening value for silver (2.6 parts per million (ppm), dry weight, 99th percentile of results throughout Virginia) was exceeded at 1ASOT001.44 in July 1995 and April 1999 and at 1ASOT001.65 in March 2004. As stated by the VA DEQ 303(d) fact sheet, "*As a result, the Aquatic Life Use goal is noted with an observed effect*" (DEQ, 2004a).

Fish sampling was conducted in 2001 and 2004 and analyzed for metals. Results from fish tissue data collected in August 2001 at station 1ASOT001.44 revealed an exceedance of the risk-based Tissue Screening Value (TSI) of 0.072 parts per million (ppm) for arsenic. As stated by the VA DEQ 303(d) fact sheet in reference to this exceedence, "*As a result, the Fish Consumption Use goal was assessed as fully supporting with an observed effect*" (DEQ, 2004a). However, results from fish tissue sampled in July 2004 did not show any metals exceedances.

Organics data collected on South Run include water column and sediment samples analyzed for chlordane, dieldrin, endosulfan, endrin, heptachlor epoxide, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), and PCBs. All available organics data collected in South Run were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards and sediment screening values.

Organics concentrations were below detection limits for the majority of the samples analyzed. No monitored organics parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Additionally, none of the available sediment organics data violated the sediment screening values specified in the DEQ assessment guidance memorandum (DEQ, 2004). Fish tissue sampling conducted in 2001 and 2004 also tested for organics. Results from these tests did not show any exceedences of the risk-based Tissue Screening Value for organic chemicals.

3.1.6 Toxicity Testing

Toxicity testing was performed on water samples collected on South Run by DEQ on April 12th, 14th, and 16th, 2004 and on May 2, 2005 at station 1ASOT001.65. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and *Ceriodaphnia dubia* as test organisms. Results for samples analyzed in April 2004 indicated *Ceriodaphnia* mortality and reproduction in the South Run water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects to *Ceriodaphnia* in the South Run samples. In 2004, fathead minnow growth in the South Run water samples was also not statistically different from growth in the control samples. However, fathead minnow survival in samples collected at station 1ASOT001.65 did significantly vary from minnow survival in the control samples. Minnow survival in samples collected at station 1ASOT001.65 was 50%, which was statistically different from the laboratory control and indicated the potential for toxicity in the South Run water samples collected in 2004.

Toxicity results for samples taken in May 2005 indicated that there were there were no toxic water column effects to *Ceriodaphnia* in the South Run water samples. However, fathead minnow survival in samples collected at station 1ASOT001.65 did significantly vary from minnow survival in the control samples. In addition, test samples also significantly affected the biomass of the fathead minnows.

In addition to being statistically different from the laboratory control, the effects observed in both 2004 and 2005 were probably biologically significant. However, these observed effects should be correlated with other available water quality parameters to determine the presence of toxicity (EPA, 2004; EPA, 2005a).

3.2 Supplemental Monitoring Data

3.2.1 Occoquan Watershed Monitoring Lab

The Occoquan Watershed Monitoring Laboratory (OWML), which is operated by the Virginia Polytechnic Institute Department of Civil Engineering and was established by mandate of the Occoquan Policy, has conducted water quality monitoring efforts throughout the Occoquan River Basin since its establishment in 1972. **Table 3-9** lists the OWML stations found in the watershed, the type of monitoring conducted, the period of record, and the number of sampling events conducted.

Table 3-9: Inventory of South Run Occoquan Monitoring Lab Data

Site ID	Station Location	Data Type	Sampling Period	Number of Sampling Events
BR02	South Run	Ambient	January 1994- December 2004	296
		Organics	January 1994-October 2004	43
BR03	South Run	Ambient	January 1994- December 2004	295
		Organics	January 1994-October 2004	43
BR07	South Run (immediately below dam)	Ambient	January 1994- December 2004	296
		Organics	January 1994-October 2004	42

Ambient water quality measurements at stations BRO2, BRO3, and BRO7 show results generally comparable to those reported in the VA DEQ data. Temperature and pH have been in compliance with Virginia's numeric criteria for Class III waters throughout the sample record. In general, total phosphorus and nitrogen were low across all sample stations (total phosphorus Max: 0.43, Min: 0.01, Avg. 0.06; total nitrogen Max: 2.45, Min: 0.66, Avg. 1.17). However, total nitrogen data from these three sampling stations in the watershed did show spatial variability. This variation is largely the result of nitrate, which comprises on average, 69% (BRO2), 42% (BRO3), and 26% (BRO7) of the total nitrogen samples. Nitrate concentrations were observed to be significantly different between station BRO7 and stations BRO2 and BRO3 ($P < 0.05$; 0.22 ± 0.13. 1.08 ± 1.48, and 0.42 ± 0.51).

The Occoquan Watershed Monitoring Laboratory (OWML) collected dissolved organic samples quarterly between 1994 and 2004 at stations BR02, BR03, and BR07 located on South Run. Dissolved organics samples collected were analyzed for total of 53 parameters including acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluroanthene, benzylbutyl phthalate, beta-benzene hexachloride, chrysene, biben(a,h)anthracene, dieldrin, diethyl phthalate, dimethyl phthalate, dicotyl phthalate, fluoranthene, fluorene, hexachlororbenzene, heptachlor, malathion, napthalene, and simazine. Dissolved organics concentrations were below detection limits for the majority of the samples analyzed. All available organics data collected on South Run were analyzed to determine whether the examined parameters complied with Virginia's water quality standards. Twenty of the 53 organics parameters tested by OWML currently do not have limits listed in Virginia Water Quality Standards. No monitored dissolved organics parameters exceeded Virginia Sate acute or chronic dissolved freshwater criteria. However, on January 1, 1996 samples analyzed for benzo(a)pyrene collected at BR02, BR03, and BR07 did exceed Virginia's human health standards for all surface waters other than those used for public water supply.

3.3 Discharge Monitoring Reports

As stated in Section 2.2, there is one facility, the Vint Hill Farms WWTP, holding an active individual permit in the South Run watershed (**Table 2-4**). Upon future expansion of Vint Hill Farms, the current outfall location for the facility will be moved from South Run to Kettle Run as the receiving stream. DMR data for the Vint Hill facility are presented in **Figures 3-13** to **3-21**.

Flow data for the Vint Hill facility are presented in Figure 3-11. Dissolved oxygen concentrations have been in compliance with permitted effluent limits (**Figure 3-14**). Biological oxygen demand concentrations are generally low for the period of record, but appear to fluctuate more widely over the past two years (**Figure 3-15**). Several recent exceedances of the biological oxygen demand permitted limit were observed in the DMR data. pH values were within the acceptable range for the period of record (**Figure 3-16**), and total suspended solids concentrations were generally low in the Vint Hill WWTP effluent (**Figure 3-17**). Nutrient effluent concentrations were elevated, and on several occasions exceeded the permitted limits established for ammonia and total phosphorus (**Figures 3-18** and **3-20**). Elevated nitrate as nitrogen levels were recorded and these levels exceeded the future effective nitrate as nitrogen limits. This limit becomes effective on October 1, 2007 and the permit includes a four-year compliance schedule for achieving compliance with final effluent limits **(Figure 3-19).** All observed fecal coliform bacteria concentrations were below permitted limits (**Figure 3-21**).

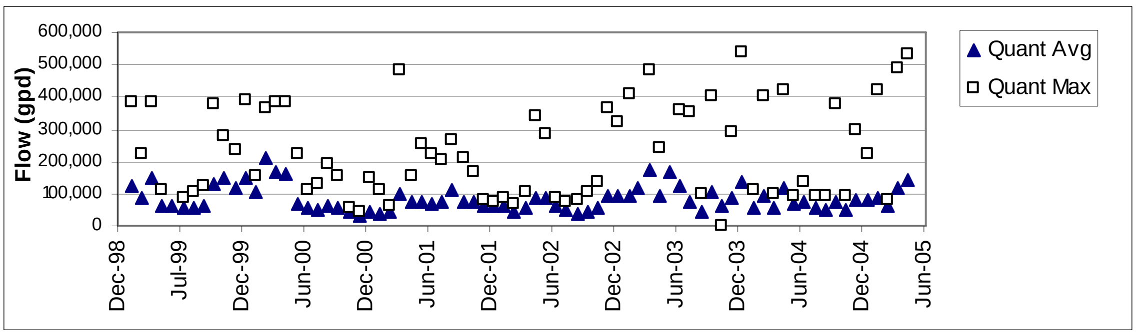

Figure 3-13: Vint Hill Effluent Flow Values

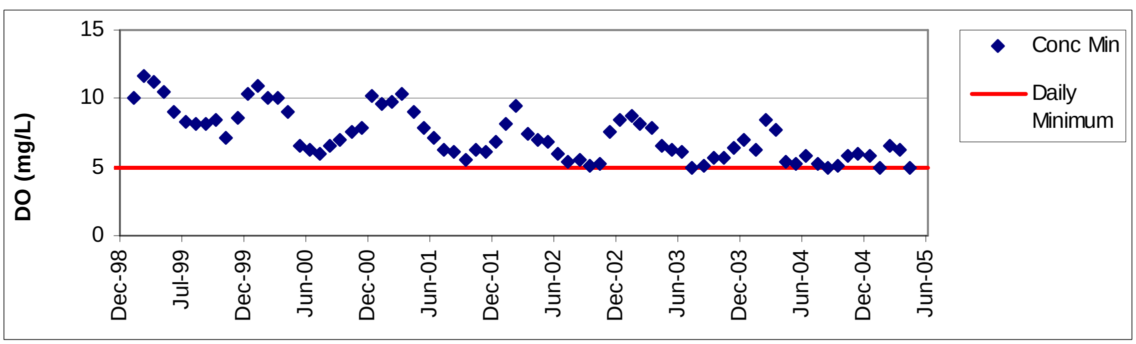

Figure 3-14: Vint Hill Effluent Dissolved Oxygen Concentrations

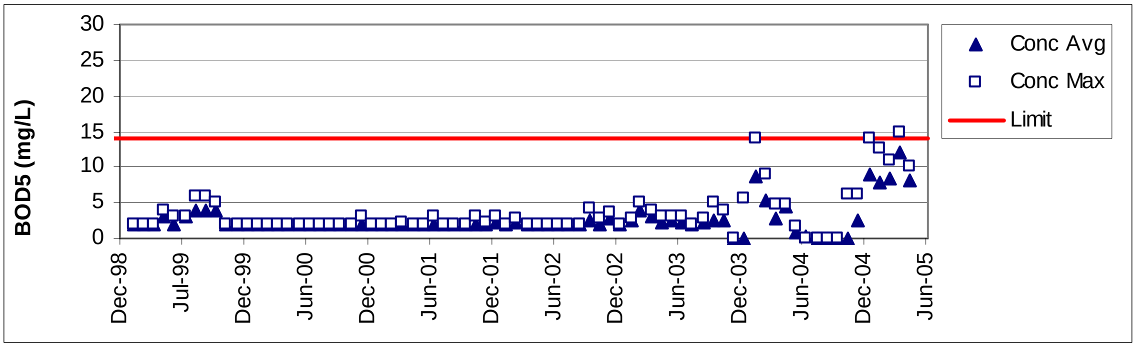

Figure 3-15: Vint Hill Effluent BOD Concentrations

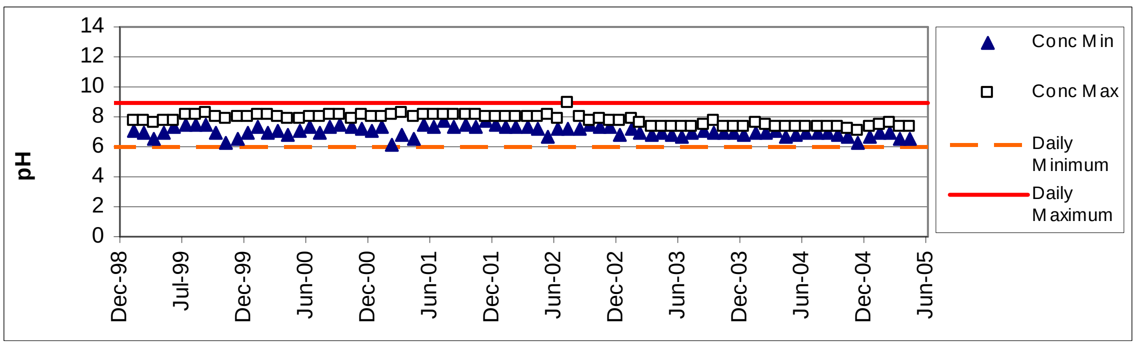

Figure 3-16: Vint Hill Effluent pH Values

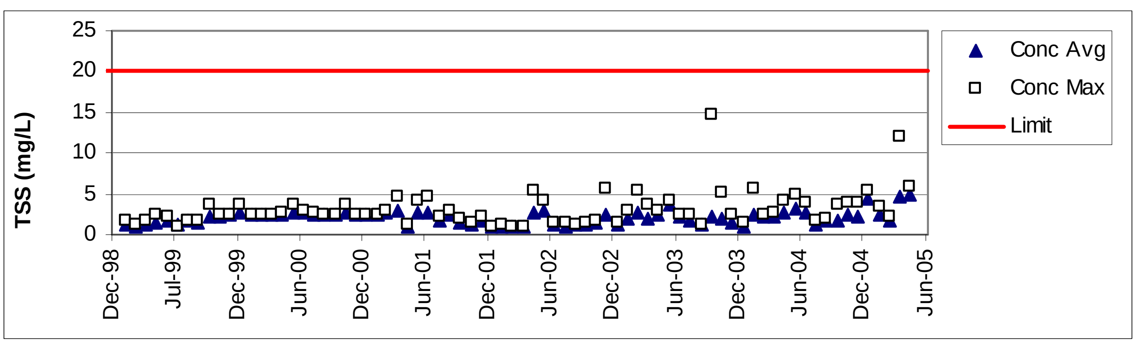

Figure 3-17: Vint Hill Effluent Total Suspended Solids Concentrations

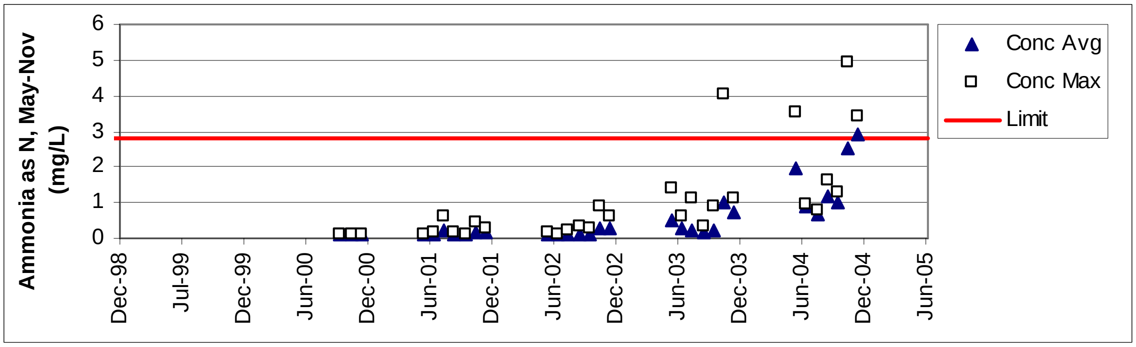

Figure 3-18: Vint Hill Effluent Ammonia Concentrations

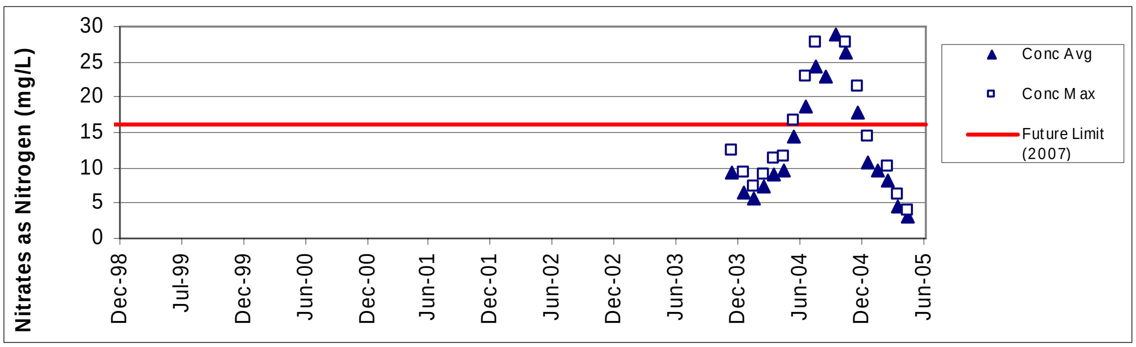

Figure 3-19: Vint Hill Effluent Nitrate Concentrations

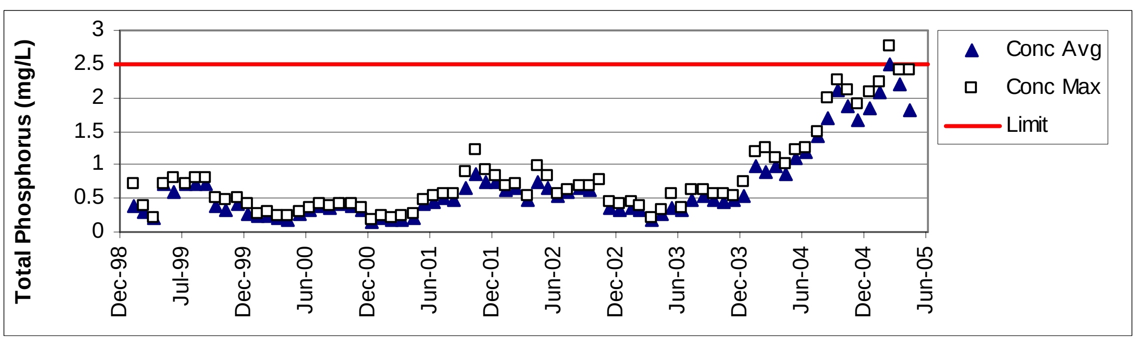

Figure 3-20: Vint Hill Effluent Phosphorus Concentrations

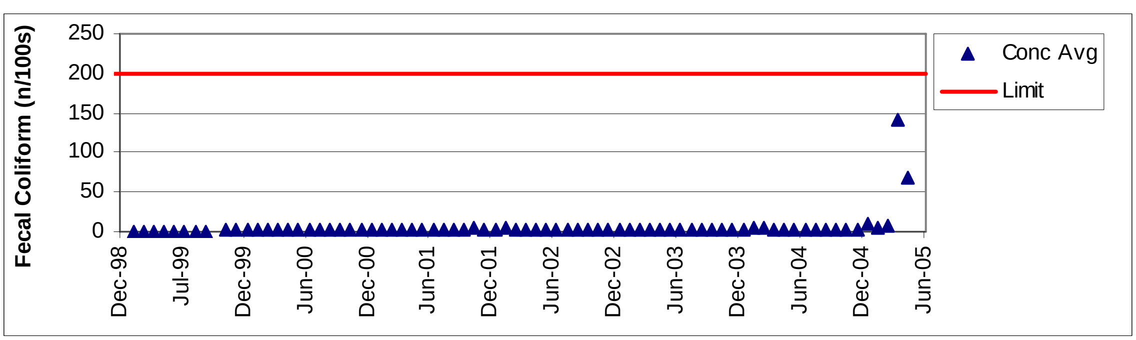

Figure 3-21: Vint Hill Effluent Fecal Coliform Concentrations

4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of South Run was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA 2000).

The identification of the most probable cause of biological impairment in the South Run watershed was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as pH, temperature, dissolved oxygen, sediment, ammonia, flow modification, and toxic compounds. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with conclusive data linking them to the poorer benthic community. **Table 4.1** summarizes the results of the analysis.

Table 4-1: Summary of Stressor Identification in the South Run Watershed

Parameter	Location in Document
Non-Stressors	
Temperature and pH	Section 4.1.1
Organic Chemicals	Section 4.1.2
Dissolved Oxygen	Section 4.1.3
Possible Stressors	
Metals (Silver and Arsenic)	Section 4.2.1
Toxicity	Section 4.2.2
Most Probable Stressors	
Nutrient Enrichment	Section 4.3.1

4.1 Non-Stressors

4.1.1. Temperature and pH

Benthic invertebrates require a suitable range of temperature and pH conditions. Although these ranges may vary by invertebrate phylogeny, high instream temperature values and either very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms.

Virginia Class III water quality standards identify the acceptable pH and temperature ranges for South Run to protect aquatic communities and habitats. Field measurements show that there have been no observed violations of water quality standards for temperature (**Figure 3-4**). A few exceedences of the minimum pH standard were recorded in 2001, and one exceedence of the maximum pH standard was recorded in 2005 (**Figure 3-6**). Therefore, temperature and pH are not anticipated to be adversely impacting the benthic communities in the South Run and are classified as non-stressors.

4.1.2. Organic Chemicals

Dissolved (water column) organic parameters (aldrin, dieldrin, endosulfan, endrin, DDD, DDE, DDT, PAHs, and PCBs) did not exceed acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Organic concentrations were below detection limits for almost all of the samples analyzed.

Additionally, none of the sediment organic available data exceeded the sediment screening values specified in the DEQ 2006 assessment guidance memorandum.

Therefore, organic compounds are not anticipated to be affecting the benthic macroinvertebrates in the South Run, therefore are classified as non-stressors.

4.1.3. Dissolved Oxygen

Adequate dissolved oxygen (DO) levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream DO levels can result in DO depletion or anoxic sediments, which adversely impact the river's benthic community.

Field DO data presented in **Figure 3-2** indicates adequate DO levels in the impaired segment of the South Run watershed. Similarly, the DO diurnal study conducted between August 3 and August 5, 2005 shows that DO levels remained above the minimum DO standards (**Figure 3-3**). However, it should be noted that the data show a large diurnal DO swing of approximately 4 mg/L which is indicative of streams with high biotic production and the presence of eutrophication processes. These processes are generally caused by excessive nutrient loads.

In summary, despite the presence of diurnal DO swings and eutrophic conditions, the ambient water quality monitoring data show adequate levels of DO in South Run. Therefore, based on the ambient data, DO is not anticipated to be directly affecting the benthic communities in the South Run and is considered a non-stressor.

4.2 Possible Stressors

4.2.1 Metals (Silver and Arsenic)

All available dissolved (water column) metals data (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc) were below the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. Sediment screening values in both 2001 and 2004 exceeded the consensus based probable effects concentration (PEC) sediment screening value for silver. In addition, fish tissue data in 2001 revealed an exceedance for arsenic. VADEQ's 303(d) fact sheets stated that observed effects on the aquatic community were noted in reference to these exceedences (2004). However, fish tissue samples taken in 2004 did not result in any exceedences of any metal concentrations.

The likely source of these metals found in South Run is from the Vint Hill Farms Station (VHFS). During World War II, VHFS served as a refitting station for units returning from combat before overseas deployment. In 1961, the U.S. Army Electronic Material Readiness Activity was moved to VHFS. In 1973, U.S. EPA took over operation of the photographic interpretation center from the Defense Intelligence Agency which was renamed the Environmental Photographic Interpretation Center (EPIC). VHFS went under the Major Subordinate Command of Communications-Electronics Command

(CECOM) and was named to the Base Realignment and closure (BRAC) list in 1993 (EPA, 2005b). The photographic processing and military construction that took place at Vint Hill in the past is a likely source of metals found in South Run. Since silver and arsenic are no longer being discharged from Vint Hill, the levels of these metals in the ecosystem should continue to decrease. Since these metals were detected within South Run, they are classified as possible stressors.

4.2.2 Toxicity

Ammonia levels, which are toxic to aquatic organisms in high concentrations, were low across all monitoring stations suggesting that ammonia is not adversely impacting benthic invertebrates in the biologically impaired segments of South Run watershed.

Toxicity testing was performed on water samples collected on South Run by DEQ on April 12th, 14th, and 16th, 2004 and on May 2, 2005 at station 1ASOT001.65 Results indicated that there were no toxic water column effects to *Ceriodaphnia* in the South Run samples taken in 2004 and 2005. However, fathead minnow survival did vary from minnow survival in the control samples indicating the presence of toxicity in the South Run water samples taken in 2004 and 2005.

The EPA Region 3 laboratory in Wheeling, WV reported that, in their professional judgment, the difference in mortality rates between the samples taken at station 1ASOT001.65 and the control was "*probably biologically significant*." However, in both instances, the laboratory emphasized that these results were qualitative in nature, and needed to be compared to other available water quality data.

At present, review and assessment of the available water quality data provides no direct link to a potential toxic substance. However, the fish tissue and sediment metals data identified that there is a potential toxic effect in South Run. The toxicity testing results are insufficient to suggest that there is a toxicity affect directly impacting the benthic community, and therefore instream toxicity is only considered a possible stressor in the impaired segment of South Run.

4.3 Most Probable Stressors

4.3.1 Nutrient

Excessive nutrient inputs can lead to eutrophication (algal blooms) and low DO concentrations, which may adversely affect the survival of benthic macroinvertebrates. In particular, DO levels may become low during overnight hours due to respiration. Similarly, excessive organic matter can lead to low in-stream DO concentrations that may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of nutrients include runoff from urban and agricultural areas and point source dischargers. Potential sources of organic matter include wastewater discharges, agriculture land use, and urban runoff.

Although the diurnal or the ambient monitoring DO data did not show an exceedence of the minimum standard it did show daily DO swings indicative of high levels of biotic production and the presence of eutrophication processes related to excessive nutrient loads. This suggestion is supported by DEQ field biologists who noted that excessive filamentous algae, commonly caused by the use of fertilizers with a high nutrient content, are present in South Run. In addition, organic enrichment in South Run is confirmed by a lower EPT taxa count and consistently high MFBI scores, which are indicative of a relatively tolerant community and of organic enrichment. This has been specifically noted in the biologist's field notes which stress that the "s*ite is frequently dominated by a facultative and tolerant community which is indicative of organic enrichment".*

Available ambient total phosphorus water quality data in South Run are presented in **Figure 4-1**, which also depicts the VA DEQ's reference values for the mean, 75th percentile, and median. The VA DEQ's reference values for ecoregion 9 are defined in the "*December 2005 Draft Report of the Academic Advisory Committee to Virginia Department of Environmental Quality: Freshwater Nutrient Criteria for Rivers and Streams*". The data in **Figure 4-1** show that the majority of total phosphorus concentrations exceeded the median reference value and on many occasions the 75th percentile and mean reference values for South Run.

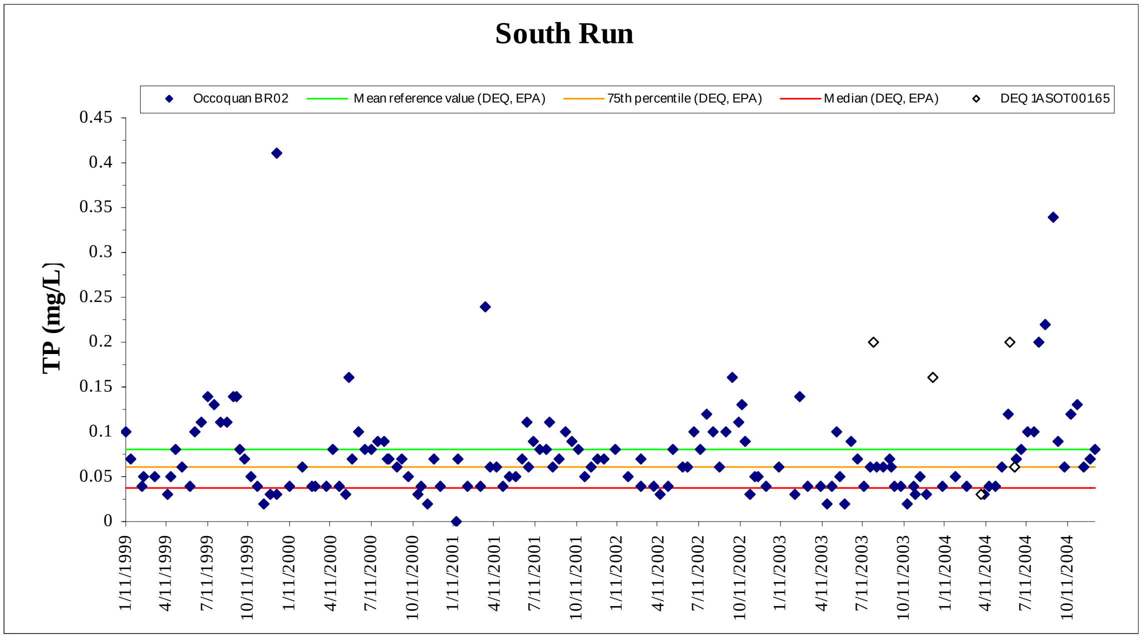

Figure 4-1: Ambient Total Phosphorus in South Run Creek between 1999 and 2005

As discussed in Chapter 3, ambient dissolved oxygen measurements taken over the last 10 years indicate that DO levels are in compliance with the VA DEQ dissolved oxygen standards. Similarly, compliance with this standard was observed in the continuous diurnal DO measurements taken over a two-day period during the first two weeks of August 2005. However, the continuous diurnal DO measurements showed large swings over the two day period of continuous DO measurements **(Figure 4-2)**. The swings (the largest were approximately 4 mg/L corresponding to fluctuations in DO saturation between 70 and 119 percent) are indicative of the presence of eutrophication processes in the stream and may cause DO violations that were not captured within the limited diurnal DO sampling period.

To investigate the potential for DO violations occurring in South Run during the summer months, a potential DO diurnal swing of 4 mg/L was applied to the observed August 2004 ambient DO data. The result of the analysis is presented in **Figure 4-3**, which shows that frequent exceedances might occur when the potential diurnal swing is taken into consideration and applied to the South Run ambient DO data.

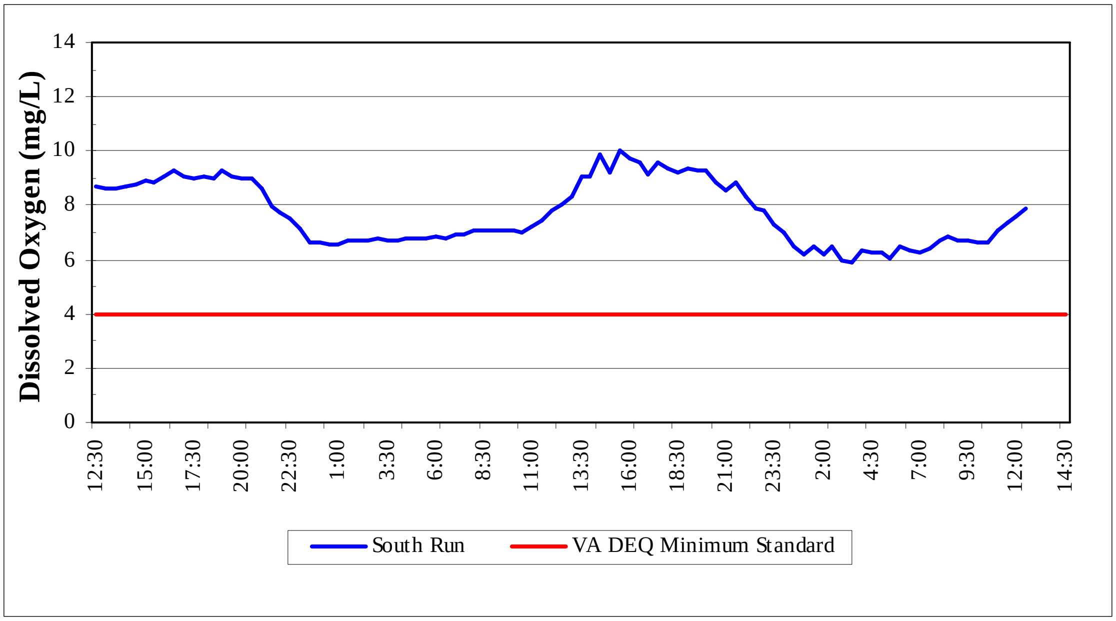

Figure 4-2: Diurnal Dissolved Oxygen in South Run - August 2-3 2004

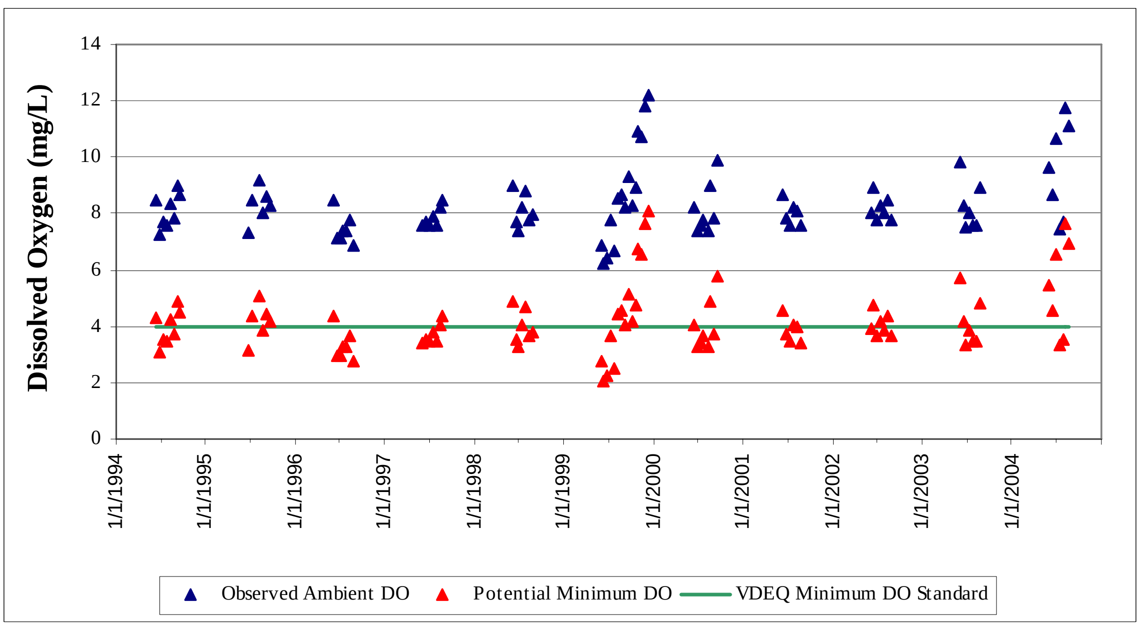

Figure 4-3: Ambient Dissolved Oxygen and Potential Minimum DO in South Run (Summer Months)

Available ambient total nitrogen water quality data in South Run are presented in **Figure 4-4**. Similar to total phosphorus, of the majority of the total nitrogen concentrations exceeded the VADEQ reference values. Therefore, the data analyzed so far indicates that there is excessive productivity in South Run caused by excessive nutrient. In order to identify which specific nutrient is limiting (the nutrient causing excessive eutrophication), the N/P ratio was calculated. On the average, the N/P ratio in South Run ranges between 11.6 and 25, with an average ratio of 18. This N/P ratio is based on nutrient observations taken by the OWML at Station BR02. A N/P ratio greater than 7 (Chapra, 1997) suggests that the stream is phosphorus limited, and phosphorus controls the level of production in South Run. Therefore, total phosphorus was identified as the most probable stressor in South Run.

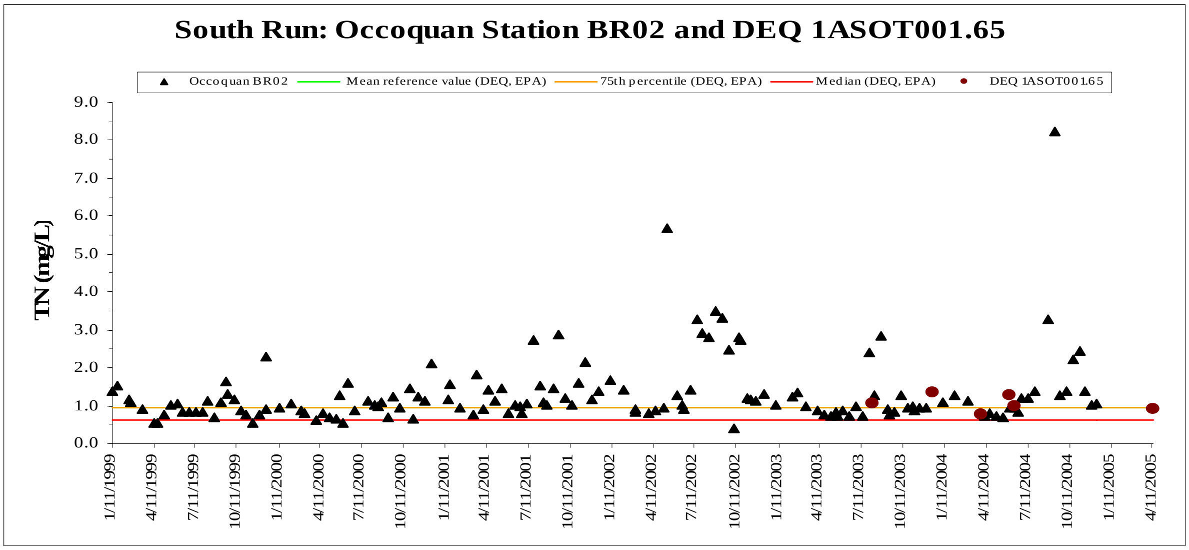

Figure 4-4: Ambient Total Nitrogen in South Run Creek between 1999 and 2005

Taken together, observed trends in nutrient levels and DO, as well as biological field notes from sampling efforts, indicate the presence of eutrophic processes in South Run. Based on the data presented, the elevated phosphorus concentrations and its associated impacts on biologic activity are responsible for the severe diurnal DO fluctuations observed in South Run. Therefore, phosphorus is classified as the most probable stressor causing the habitat alterations in the South Run watershed.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that DO, temperature, and pH in the biologically impaired segment of South Run are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. In addition, concentrations of organic chemicals were generally low, or below analytical detection limits, and are classified as non-stressors.

The instream toxicity testing suggested the presence of potential toxicity in South Run. However, the toxicity data is still inconclusive, due to a lack of support for a toxic effect in the available water quality data. As a result, instream toxicity is considered only as a possible stressor in the impaired segment of the South Run watershed.

Based on the sediment and fish tissue data, silver and arsenic are also classified as possible stressors. The photographic processing and military construction that took place at Vint Hill in the past is a likely source of silver and arsenic. Since silver and arsenic are no longer being discharged from Vint Hill, the levels of these metals in the ecosystem should continue to decrease.

Based on the data discussed in the preceding sections, phosphorus has been identified as the primary stressor impacting benthic invertebrates in the biologically impaired segment of South Run. Furthermore, total phosphorus is the primary stressor based on the DO diurnal study and the N/P ratio in South Run. Potential sources of this nutrient in the watershed include urban stormwater runoff, agricultural runoff, and point source dischargers, as well as Lake Brittle, which is may be contributing to the total phosphorus enrichment in the impaired segment of South Run.

Improvement biologically impaired community in South Run is dependent upon controlling the contributing phosphorus loads. To address these issues, a total phosphorus TMDL will be developed for the biologically impaired segment of the South Run watershed.

5.0 TMDL Endpoint Identification

TMDL development requires the determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, a reference watershed approach may be used to define the TMDL endpoint.

South Run was initially included on the Virginia Section 303(d) list for violations of the General Standard (benthic impairment). As detailed in Section 4.0, nutrient enrichment because of excessive phosphorus levels was identified as the most probable stressor causing the benthic impairment in the river. Currently, Virginia does not have numeric criteria for nutrients. Therefore, a reference watershed approach was used to establish the numeric nutrient TMDL endpoint for South Run.

5.1 Reference Watershed Approach

Under the reference watershed approach, the TMDL endpoint for an impaired watershed is established based on conditions in a similar, but non-impaired (for the TMDL endpoint) reference watershed. In terms of benthic impairment caused by excessive nutrients, the TMDL endpoint is the nutrient loading rate in the non-impaired reference watershed. Reduction of the nutrient loading rate in the impaired watershed to levels comparable to the reference watershed is assumed to be sufficient for recovery of the benthic community in the impaired watershed.

Selection of an appropriate reference watershed is based on similarities in watershed characteristics such as soils, topography, land uses, and ecology. Similar watersheds help to ensure similarities in the benthic communities that potentially may inhabit the streams. Similar watersheds also provide for similar watershed hydrology which influences pollutant loading rates to the stream.

5.2 Selected Reference Watershed

The Popes Head Creek watershed was selected as the reference watershed for the South Run benthic TMDL development. The Popes Head Creek reference watershed is located about 14 miles west of South Run and is within the Occoquan watershed. Both the South Run and Popes Head Creek watersheds are located primarily in the Northern Piedmont ecoregion. The sizes of the watershed differ, since Popes Head Creek watershed covers 12,119 acres, while South Run covers 4,487 acres. This difference in area will be addressed during modeling. **Table 5-1** summarizes important criteria considered in the selection of the reference watershed for the South Run. **Figure 5-1** displays a map of the reference watershed.

Table 5-1: Criteria Used in Reference Watershed Selection

Criteria	Relevance
Ambient Monitoring Data	Ambient Monitoring data is required to confirm the non-impairment status of the reference watershed and allows for comparisons with the impaired watershed.
Ecoregion	The reference and impaired watersheds should belong to the same ecoregion to help ensure similarities in stream ecology.
Topography	Topography influences hydrology and is a major component of stream habitat that affects the structure and composition of benthic communities.
Land Uses	The selected reference watersheds should reflect similar land use distributions. The water quality of streams in a watershed is greatly influenced by land use. Similar land use distributions help to establish achievable TMDL endpoints.
Soils	Soil composition influences watershed runoff, erosion, and stream ecology.
Watershed Size	The reference watershed should be similar in size to the impaired watershed since watershed area influences pollutant loading rates to the stream.
Location	Close proximity to the impaired watershed generally improves overall watershed similarity. In addition, the reference watershed should be near a weather station that may be used to characterize precipitation at both watersheds in order to standardize model simulations.

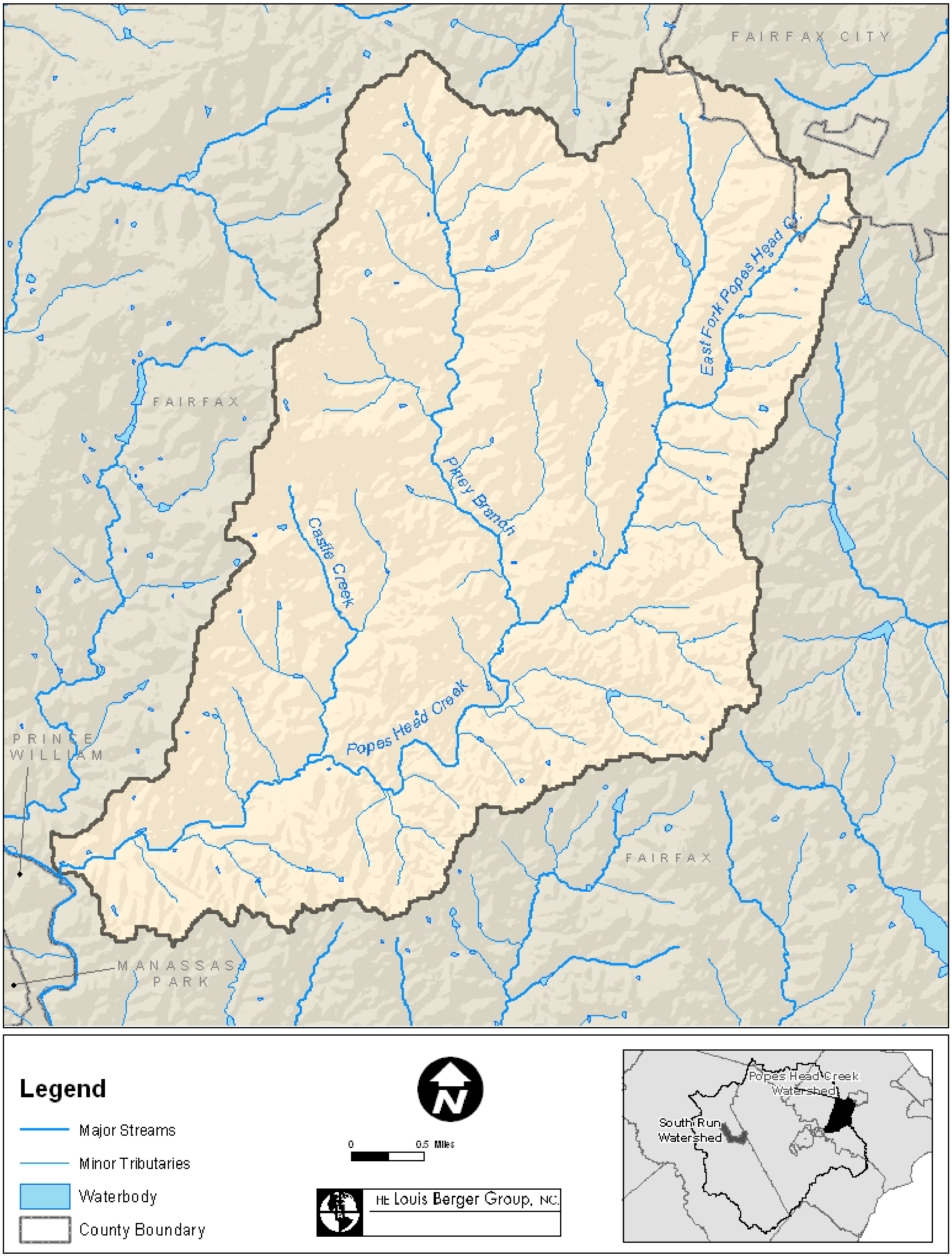

Figure 5-1: Popes Creek Reference Watershed

5.2.1 Ambient Monitoring Data in the Reference Watershed

The ambient monitoring data is required to confirm the phosphorus-non-impairment status of the reference watershed and allows for comparisons with the impaired watershed. Available ambient total phosphorus water quality data in Popes Head Creek collected at DEQ station 1APOE002.00 are presented in **Figure 5-2**. VA DEQ's reference values for the mean, 75th percentile, and median are also plotted with the TP ambient data in Popes Head Creek. The data show that the majority of observed total phosphorus concentrations remained below the reference values for Popes Head Creek confirming its phosphorus-non-impaired status.

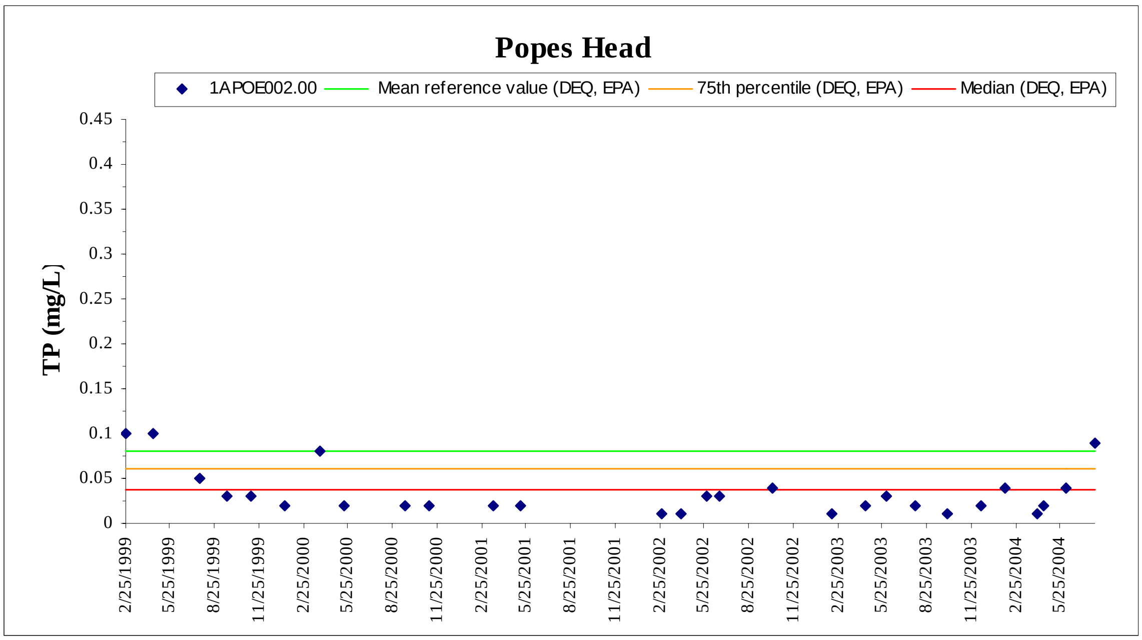

Figure 5-2: Ambient Total Phosphorus in Popes Head Creek between 1999 and 2005

The diurnal dissolved oxygen measurements recorded at DEQ station 1APOE002.00 on Popes Head Creek in August 2004 are displayed in **Figure 5-3.** In contrast to South Run, the diurnal data indicates normal DO variations of approximately 1 mg/L corresponding to DO saturation fluctuations between 85 and 100 percent.

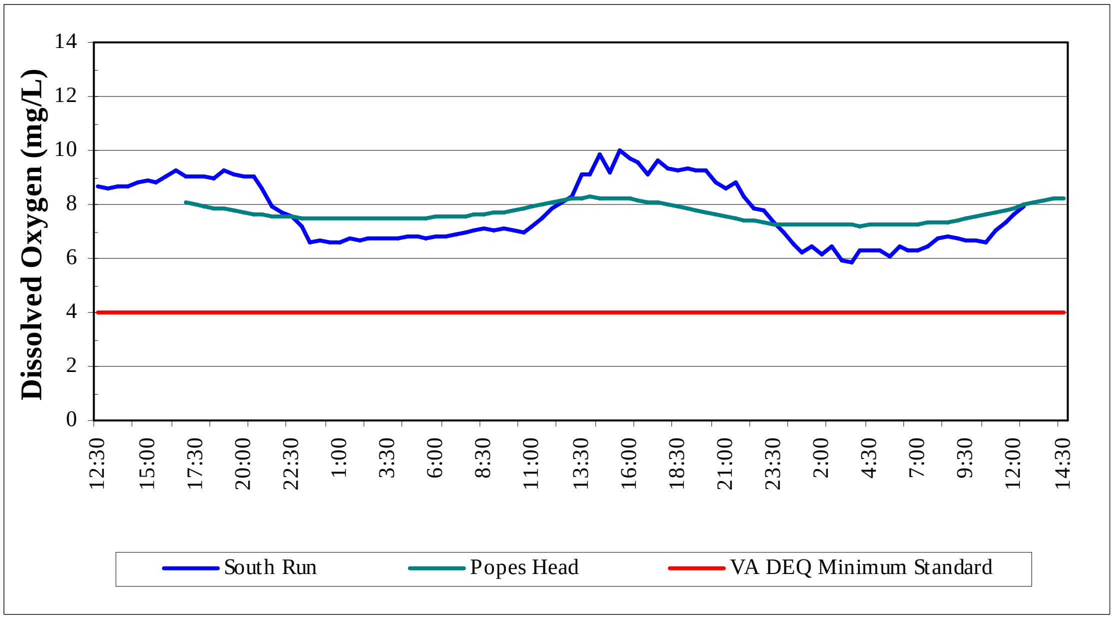

Figure 5-3: Diurnal Dissolved Oxygen in Popes Head Creek and Bull Run Creek

Due to the normal daily DO cycle and low phosphorus concentrations, Popes Head is considered non-impaired for total phosphorus and therefore was used as a reference site to determine the total phosphorus TMDL endpoint.

5.2.2 Land Use

A comparison of land use distributions in the South Run impaired and Popes Head Creek reference watersheds is provided in **Table 5-2**. South Run and Popes Head Creek and watersheds are forested at 35% and 38%, respectively. South Run is composed of a higher percent of agricultural lands at 34% in comparison to Popes Head Creek at 5%. Also, Popes Head has a higher percentage of urban land use at 57% in comparison to 31% in South Run. This difference in the percentage of urban land use is expected, since the headwaters of Popes Head Creek flow through the western section of the City of Fairfax and the entire watershed is located within rapidly urbanizing Fairfax County. It should be noted that the majority of the developed lands present in Popes Head Creek watershed are zoned for 2-acre and 4-acre lots which are comprised of less impervious surfaces those than typically observed in urban areas.

Table 5-2: Summary of Land Use Distributions for South Run Impaired and Popes Head Creek Reference Watersheds

Land Use Category	% of Total Watershed	
	South Run	Popes Head
Forest	35	38
Agricultural	34	5
Developed	31	57
Barren	0	0
Total	**100**	**100**

5.2.3 Soils Distribution

A summary of the soils distributions for South Run impaired watershed and Popes Head reference watershed are provided in **Table 5-3**. Hydrologic soil groups represent the different levels of soil infiltration capacity. The soil series in both, the impaired watershed (South Run) and the reference watershed (Popes Head Creek), consist of soils of hydrogroups B and C, and therefore have moderate to slow infiltration rates. South Run has a greater proportion of soils with moderate to slow infiltration rates, therefore a slightly higher potential for conversion of rainfall to runoff during storm events.

Table 5-3: Summary of Soil Distributions for South Run and Popes Head Creek

Hydrologic Group	% of Total Watershed	
	South Run	Popes Head
A	0	3
B	32	69
C	53	9
D	13	16
C/D	2	3

6.0 Nutrient Load Determination

A reference watershed approach was used to develop the total phosphorus TMDL for the South Run watershed as discussed in the previous section. The reference watershed identified for this impaired segment was Popes Head **(Figure 5-1)**. The total phosphorus loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, total phosphorus loadings were determined for both the reference and impaired watersheds in order to quantify total phosphorus loading reductions necessary to achieve the designated aquatic life use for South Run.

6.1 Total Phosphorus Source Assessment

Total phosphorus can be delivered to the stream from point sources located in the watershed, nonpoint source runoff from urban and agricultural lands, and nonpoint sources through seepage from groundwater in dissolved phosphorus forms. These processes adversely impact the benthic macroinvertebrate community through degradation of water quality.

Potential total phosphorus sources within the South Run watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Point Sources

There is currently only one individually permitted facility holding an active individual permit in the South Run watershed (**Table 2-4**).

6.1.2 Nonpoint Sources

Nonpoint Source Runoff

The land use types in the South Run watershed were characterized using a combination of NLCD and NVRC data and the distribution was presented in **Table 2-3.** The soil types were characterized using the STATSGO database and a summary of soil types and the associated hydrologic soil groups are provided in **Table 2-1** and **2-2**. Total phosphorus loadings from generalized land use types present in the South Run watershed are discussed below.

Forested Lands

Total phosphorus loads from forested lands are typically low. This load is considered background condition.

Agricultural lands

Agriculture lands can be a dominant source for total phosphorus loads originating from excessive fertilizer application on cropland and pasturelands.

Developed Lands

Phosphorus loads from urban areas are mainly associated with excessive fertilizer application on areas such as yards, parks, playgrounds, and golf cources.

Water/Wetlands

The amount of total phosphorus loading from water and wetland areas typically is not significant.

Barren Lands

Transitional lands represent areas of sparse vegetative cover often due to land use activities such as forest clearcuts and construction lands. Total phosphorus loads from transitional lands are typically low.

Nonpoint Source through seepage from groundwater

Nonpoint sources entering through seepage include dissolved inorganic and/or organic phosphorus forms and originate from agricultural phosphorus application and septic systems. Both sources have generally a low impact on total phosphorus levels in the seepage because of the high capacity of soils to precipitate out phosphorus with calcium and to adsorb phosphorus to iron or aluminum oxides/hydroxides.

Nonpoint Source through Lake Brittle

The Department of Game and Inland Fisheries (DGIF) conducted a nutrient study on Lake Brittle between October 1988 and September 1989. The study recorded concentrations at the inlet and outlet of Lake Brittle (DGIF, 1989). DGIF concluded that “no increase in total phosphorus” was determined between the inlet and outlet of Lake

Brittle. The phosphorus concentration was 0.1 mg/L for both the inlet and outlet. In addition, the water quality study concluded that Lake Brittle acts “as a phosphorus sink”. Therefore, based on this study from 1989, Lake Brittle does not have a significant impact on the total phosphorus concentrations in South Run.

6.2 Technical Approach for Estimating Total Phosphorus Loads

6.2.1 Point Source Loadings

There is one individual point source facility in the South Run impaired watershed that discharges directly into South Run (**Table 6-1**).. For the purpose of TMDL development, annual point source loadings were computed for the individual point source facility based on the existing average flow and total phosphorus concentrations based on discharge monitoring report (DMR) data in 2004 (Total phosphorus concentrations were not available in the DMR data. It was assumed that Vint Hill Farms WWTP organic phosphorus loads were insignificant compared to dissolved phosphorus loads.)

Table 6-1: Point Sources in the South Run Impaired Watershed

Facility Name	Permit Number	Permitted Load (kg/day)	Annual Total Phosphorus Loading (ton/yr)
Vint Hill Farms WWTP	VA0020460	0.43*	0.175*

*Based on existing average flow at 0.072 MGD and concentration at 1.59 mg/L in 2004

6.2.2 Nonpoint Source Total Phosphorus

For the purpose of TMDL development, annual phosphorus loadings from nonpoint sources and groundwater were determined using the Generalized Watershed Loading Functions (GWLF) model.

GWLF is a time variable simulation model that simulates hydrology, sediment, and nutrients loadings on a watershed basis. Observed daily precipitation data is required in

GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Nutrient loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a total phosphorus delivery ratio is applied to determine the total phosphorus loadings to the stream. Total phosphorus loadings from each source area are summed to obtain a watershed total.

6.3 GWLF Model Setup and Calibration

6.3.1 GWLF Model Development

GWLF model simulations were performed for 1994 to 2004 in order to reflect the period of more recent biomonitoring assessments that resulted in the impairment listing for the South Run. In addition, the 10 year simulation period accounts for both seasonal and annual variations in hydrology and total phosphorus loading. Models were developed for both the reference and impaired watersheds. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF that facilitates the creation of model input files and processing of model results.

As stated previously, under the reference watershed approach the TMDL endpoint is based on total phosphorus loadings for the reference watershed. Since the reference watershed, Popes Head Creek, is larger than the impaired watershed, total phosphorus loadings for the reference watershed were adjusted to reflect the size of the impaired watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed.

6.3.2 Weather Data

Daily precipitation and temperature data were obtained from Upper Occoquan Sewage Authority (UOSA) station and data recorded between 1994-2004 were used for model simulations. This weather station is located within 5 miles from Popes Head Creek watershed and within 15 miles from South Run, and thus provided the most accurate precipitation and temperature coverage available for the watershed.

6.3.3 Model Input Parameters

In addition to weather data, GWLF requires specification of input parameters relating to hydrology, erosion, sediment yield, and chemical parameters including urban nutrient accumulation rates, dissolved nutrient concentrations in runoff, and solid phase nutrient concentrations in sediment. In general, the User's Guide for Basin 1.0 (Dai *et al.*, 2000) served as the primary source of guidance in developing input parameters.

Runoff curve numbers and USLE erosion factors are specified as an average value for a given source area. The NLCD land use types present in the watershed (**Table 6-2**) were used to define model source areas. Therefore, a total of 12 source areas were defined in the model. As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Runoff curve numbers were developed for each model source area in the watershed based on values published in the NRCS GWLF manual (Dai *et al.*, 2000). STATSGO soils GIS coverages were analyzed to determine the dominant soil hydrologic groups for each model source area. Evapotranspiration cover coefficients were developed based on values provided in the GWLF manual (Dai *et al.*, 2000) for each model source area.

Average watershed monthly evapotranspiration cover coefficients were computed based on an area weighted method. Initialization and groundwater hydrology parameters were set to default values recommended in the GWLF manual.

Table 6-2: Land Use Distribution Used in GWLF Model for the South Run Watershed

General Land Use Category	Specific Land Use Type	Total Acres
Forested	Deciduous Forest	995.8
	Evergreen Forest	128.5
	Mixed Forest	434.9
Agriculture	Pasture/Hay/Livestock	1467.8
	Row Crop	64.3
Developed	Low intensity residential	1252.8
	Commercial/Industrial	131.0
	Medium/High Residential	2.5
	Institutional	9.9
	Urban/Recreational Grass	0.0
Total		**4487.4**

USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple sources based on data availability. Average KLSCP values for model source areas were determined based on GIS analysis of soils and topographic coverages and literature review. The rainfall erosivity coefficient was determined from values given in the GWLF manual. The total phosphorus delivery ratio was computed directly in BasinSim.

The chemical parameters used in the GWLF simulation of nutrients include phosphorus content in sediment, groundwater concentration, phosphorus concentration in rural land uses runoff, and phosphorus accumulation rate in urban land uses runoff. The nutrient load from septic systems was estimated based on the per capita septic tank effluent load and the phosphorus plant uptake. GWLF manual (Dai et al., 2000) provides tables and figures for estimating the geographically specific parameters.

6.3.4 Hydrology Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to be implemented without calibration. Nonetheless, comparisons were made between predicted and observed stream flow for the South Run Creek impaired and reference watersheds to ensure the general validity of the model.

The Occoquan Watershed Monitoring Laboratory (OWML) station ST40 located on Bull Run below the confluence with Pope's Head Creek was selected for hydrology calibration based on the period of available monitoring data, its location in the watershed, and the proximity of the gage to the weather station used to develop the model precipitation inputs. **Figure 6-1** provides the location of the flow gage and weather station in relation to the Popes Head Creek watershed.

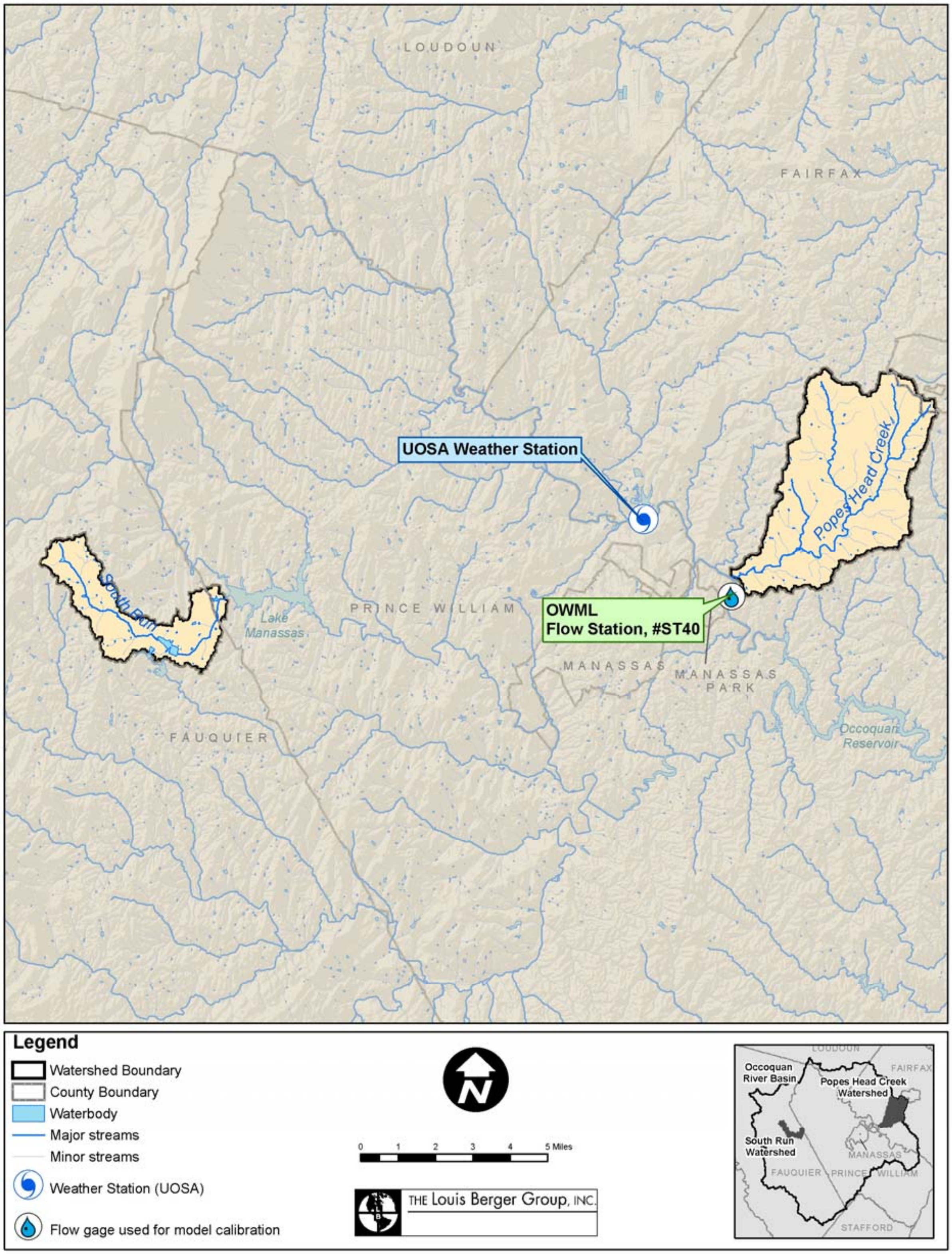

Figure 6-1: South Run Impaired and Popes Head Creek Reference Watersheds

GWLF parameters relating to hydrology were calibrated based on the flow data collected at station ST40. The groundwater seepage coefficient and the unsaturated zone available water capacity were adjusted to obtain a best fit with observed data. A visual comparison between observed and predicted flow is shown for the impaired and reference watersheds (**Figure 6-2)**.

The modeler's confidence in the accuracy of the simulation results is usually exercised by a graphical comparison between observed and predicted results. A graphical comparison between observed and predicted results is imperative and provides the first check of the accuracy of the predicted values. However, it is meant to be the first check, since its accuracy strongly depends on the scale of the presented results. Therefore, the accuracy of the simulation results can be overstated and can lead to wrong conclusions. Two statistical measures for the evaluation of the predicted results were selected. The linear regression analysis is a valuable tool for the evaluation of predicted results. It is a method for fitting an equation to a set of data using the principle of least squares to reduce the sum of the squares of the errors (McCuen, 1998). Its reliability can be tested by the coefficient of determination (R^2). The best fit is achieved when R^2 is one. The percent error is another helpful statistical method for evaluation of predicted results. The results of both evaluation tools are presented in **Table 6-3**. In general, the model predictions reflect the flow variations observed at station ST40.

Table 6-3: Hydrology Calibration Statistics

Statistic	Popes Head Watershed
R Squared ($R^{2)}$	0.7
% Error	7%

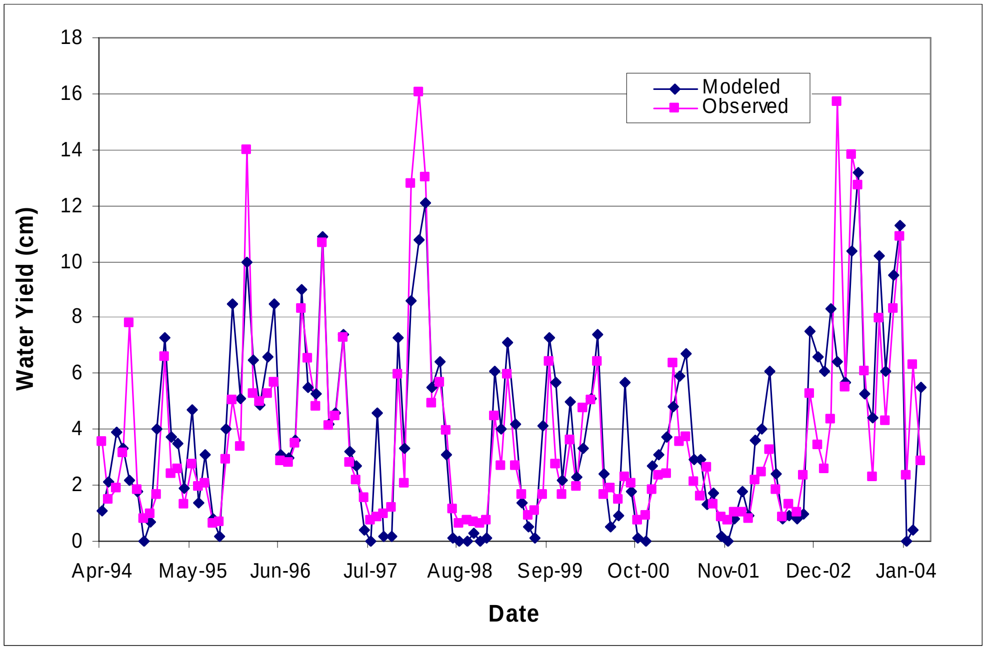

Figure 6-2: Hydrology Calibration Results for the Popes Head Watershed

Total Load Estimates

6.3.5 Total Phosphorus Loads from Point Sources

Existing total phosphorus loads from point sources within the watershed is described in Section 6.2.2.

6.3.6 Total Phosphorus Loads from Nonpoint Sources

The hydrologically calibrated model was used to estimate total phosphorus loadings from each source area in the South Run impaired and Popes Head reference watersheds. Based on the 10 year simulation period from 1994 to 2004, average annual total phosphorus loads were computed for each land source in each watershed. These results as the adjusted area weighted loads for the reference watershed are presented **Table 6-4.**

Table 6-4: South Run Average Annual Phosphorus Loads (tons/yr) from Rural and Urban Sources

Source	Impaired Watershed (ton/year)	Reference Watershed (ton/year)	Adjusted Reference Watershed (ton/year)
Transitional	0.000	0.011	0.000
Quarries/Strip Mine	0.000	0.000	0.000
Deciduous Forest	0.000	0.022	0.011
Evergreen Forest	0.000	0.000	0.000
Mixed Forest	0.000	0.000	0.000
Pasture/Hay/Livestock	0.209	0.055	0.022
Row Crop	0.044	0.011	0.000
Low intensity residential	0.099	0.389	0.143
Commercial/Industrial	0.044	0.110	0.033
Medium/High Residential	0.000	0.617	0.221
Institutional	0.000	0.077	0.022
Urban/Recreational Grass	0.000	0.011	0.000
Groundwater	0.088	0.243	0.088
Septic System	0.011	0.011	0.011
Point Source	0.173	0.000	0.000
Total	**0.669**	**1.544**	**0.562**

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Total phosphorus was identified as the primary stressor to the benthic community in the South Run impaired watershed and a reference watershed approach was used for TMDL development. The total average annual total phosphorus loading for the area-adjusted reference watershed (**Table 6-5**) represents the TMDL endpoint for the South Run impaired watershed. Reduction of total phosphorus loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for South Run.

7.1 Basis for TMDL Allocations

Total phosphorus TMDL allocations for the South Run impaired watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL = Total Maximum Daily Load (Based on the area-adjusted reference watershed total phosphorus load)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total phosphorus loading allocated to point sources. The load allocation represents the total phosphorus loading allocated to nonpoint sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

The South Run TMDL allocation scenarios presented in the next section show the effects of the phosphorus load reduction from point and nonpoint sources in the watershed.

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for the South Run to account for uncertainties in the methodologies used to determine total phosphorus loadings.

7.1.2 TMDL Wasteload and Load Allocations

Wasteload allocation is applied to Vint Hill Farms WWTP, the only individual permitted facility located within the South Run watershed. The facility is planning to expand and is in the process of relocating the discharge outfall to Kettle Run to accommodate the WWTP facility expansion and to protect Lake Manassas, a public drinking water supply source.

Load allocation will be applied to the land based loads in the watershed, and an equal percent reduction is required from all land sources except forested lands. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions.

The four scenarios considered in the south Run TMDL development are presented in **Table 7-1**. Scenarios 1-3 where used to derive scenario 4 which is the TMDL for South Run. Scenario 1 represents the existing phosphorus loading conditions where the point sources load was based on the average 2004 DMR data and the NPS load was calculated using the 10-year simulation results using GWLF model. In scenario 2, the point source load was calculated using the facility existing design flow and a permitted phosphorus concentration of 0.30 mg/l. Scenario 3 examines the point source relocation impact on the total phosphorus loading. Scenario 4 is the TMDL and is based on point source relocation but preserves 2% of the phosphorus load for the potential addition of point sources and to account for future growth in the watershed.

For Scenarios 1, 2, and 3, **Table 7-2** shows the calculated point source and nonpoint source loads and whether the total phosphorus load for each scenario is above or below the TMDL end point. Since the MOS for the TMDL is 10% of the total reference watershed load or 0.0562 tons/year, then the total point source and nonpoint source load should not exceed 0.5058 tons per year. The following is a summary of the scenarios presented in **Table 7-2**.

- Under the existing conditions, or scenario 1, the total point and nonpoint source load exceeds the TMDL end point by 32.75%. This indicates that load reduction would be necessary.

- When the permitted facility maintains discharge at the current design flow (0.247 MGD) and a phosphorus concentration of 0.30 mg/l, the exceedance of the end point is 20.4%. The reduction from 32.75 to 20.4% is basically due to reduction of the point source load from the facility by 35.43%. Additional load reduction will be necessary from the NPS to meet the TMDL end point under scenario 2.

- The impact of the facility discharge outfall relocation on the total phosphorus load is presented in Scenario 3. The total phosphorus load is below the TMDL end point. No additional reductions would be necessary under scenario 3.

Table 7-1: South Run TMDL Scenarios

Scenario		Point Source load	Nonpoint Source load
No.	Description		
1	Existing Condition	The load was calculated based on the average DMR data and current design flow.	The load was estimated based on simulation results from GWLF model.
2	Load at permitted limits	The load was calculated based on point source discharge effluent concentration of 0.3 mg/L and current design flow.	The load was estimated based on simulation results from GWLF model.
3	Facility relocation impact on loading	No load from the point source discharger. The outfall is relocated out of the watershed.	The load was estimated based on simulation results from GWLF model.
4	TMDL	Discharger outfall is relocated. However, 2% of the phosphorus load is reserved for potential future growth.	The load was estimated based on simulation results from GWLF model.

Table 7-2: Comparison of the Total Phosphorus load to the TMDL Endpoint

Scenario	Point Source (ton/year)	NPS (ton/year)	Total Load (ton/year)	End-Point (ton/year)	Comparison to the TMDL End point (%)
1	0.175	0.496	0.671	0.5058	32.66
2	0.113	0.496	0.609	0.5058	20.40
3	-	0.496	0.496	0.5058	-2
4	0.01	0.496	0.506	0.5058	0

Notes:
1. TMDL end point based on the reference watershed approach is 0.562 tons/year
2. TMDL Margin of safety is 10 percent or 0.0562 tons/year
3. The total phosphorus load from point and nonpoint source should not exceed 0.5058 tons/year.

The instream total phosphorus concentrations were calculated for scenarios 1, 2, and 3 and were compared to the established phosphorus concentrations for the Chesapeake Bay Tributary Strategies for Shenandoah and Rappahannock watersheds. The instream total phosphorus concentrations were computed using the mass balance approach based on the GWLF model predicted total phosphorus loads for nonpoint sources and DMR phosphorus loads for Vint Hill Farms WWTP. Since the model results are based on average flows, the instream concentration should be compared to the average concentration of the Tributary Strategies. As shown in **Table 7-3,** the instream phosphorus concentrations for scenarios 1, 2, and 3 are below the average phosphorus concentration recorded in the Chesapeake Bay Tributary Strategies for the Shenandoah and Rappahannock watersheds.

Table 7-3: Comparison of Instream Total Phosphorus for TMDL Scenarios to the Tributary Strategy

Scenario	Nonpoint Source[1]		Point Source		Instream P	Tributary Strategy*					
						Shenandoah River			Rappahannock River		
	mg/L	cfs	mg/L	MGD[2]	mg/L	Min	Mean	Max	Min	Mean	Max
1	0.053	9.58	1.59	0.072	**0.07**	**0.054**	**0.126**	**0.219**	**0.055**	**0.122**	**0.27**
2	0.053	9.58	0.3	0.247	**0.062**						
3	0.053	9.58	-	-	**0.053**						

[1] Based on GWLF simulation results for South Run
[2] Million Gallons per day
[3] Existing condition: Average effluent concentration and discharge in 2004
* Source: DEQ, 2005

The TMDL load reductions for the four scenarios are presented in **Table 7-4**. As shown in **Table 7-4**,

- Scenario 1 is the existing condition. The existing load exceeds the TMDL end point by 32.7%. No total phosphorus load is applied at this point.

- If scenario 2 is selected as the TMDL it would require 35.43% reduction of the phosphorus load from the point sources and 20.81% reduction of the nonpoint source load.

- Scenario 3 indicates that relocation of the point source discharge out of South Run watershed would reduce the total phosphorus load such that the TMDL end point is met without any additional reduction in the nonpoint sources.

- Scenario 4 is proposed as the TMDL for South Run since the Vint Hill Farm has already initiated plans to relocate the outfall to Kettle Run watershed. Scenario 4 requires that the point source is relocated out of the South Run watershed (100% reduction) and 2% of the nonpoint source load is preserved to account for future growth in the watershed.

Table 7-4: Phosphorus Load Reductions for Proposed TMDL Scenarios

Scenario	Load (ton/year)		Total Phosphorus Load Reduction (%)	
	PS	NPS	PS	NPS
1	0.175	0.496	0	0
2	0.113	0.393	35.43	20.77
3	0	0.496	100	0
4	0.01	0.496	2 % LA	0

7.2 Overall Recommended TMDL Allocations

The total load, wasteload allocations, and margin of safety for South Run are summarized in **Table 7-5** and the allocated total phosphorus loads and the percent reduction required for all watershed sources are presented in **Table 7-6**.

Table 7-5: Total Phosphorus TMDL for South Run (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
0.562	0.496	0.010	0.056

Table 7-6: TMDL load Allocation for the South Run

Source	Impaired Watershed (tons/year)	Reduction (%)
Transitional	0.000	0.00
Quarries/Strip Mine	0.000	0.00
Deciduous Forest	0.000	0.00
Evergreen Forest	0.000	0.00
Mixed Forest	0.000	0.00
Pasture/Hay/Livestock	0.209	0.00
Row Crop	0.044	0.00
Low intensity residential	0.099	0.00
Commercial/Industrial	0.044	0.00
Medium/High Residential	0.000	0.00
Institutional	0.000	0.00
Urban/Recreational Grass	0.000	0.00
Groundwater	0.088	0.00
Septic System	0.011	0.00
Point Source	0.01	94
Total	**0.5058**	-

7.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of South Run, the primary stressor resulting in the benthic impairment in the river is excessive phosphorus loading, which has led to eutrophication and the impairment of benthic habitat. Since phosphorus loading occurs throughout the year and its impacts on benthic invertebrates are often a function of cumulative loading, it is appropriate to consider total phosphorus loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 10 year simulation period performed using the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and total phosphorus loading as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and total phosphorus loading by using a daily time-step for water balance calculations. Therefore, the 10 year simulation performed with GWLF adequately captures seasonal variations.

8.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources in the stream. For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA, which includes a set aside for future growth, pursuant to 40 CFR 122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

8.1 Staged Implementation

In general, Virginia intends for the required BMPs to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient phosphorus BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through follow-up stream monitoring;

2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;

4. It helps ensure that the most cost effective practices are implemented first; and

5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

8.2 Stage 1 Scenarios

The TMDL allocation scenario to reduce phosphorus loading to South Run was presented in Section 7.0. Currently the phosphorus load in South Run exceeds the TMDL endpoint by 32.7%. However the only point source in the watershed, Vint Hill Farms WWTP, is in the process of relocating the outfall to Kettle Run Watershed. As a result, the phosphorous load in South Run will be reduced below the TMDL endpoint. No load reduction will be required form nonpoint sources in the watershed since the TMDL end point is met and the average concentration in South Run were below the Chesapeake Bay Tributary Strategies for the Shenandoah and the Potomac watersheds. The allocated total phosphorus loads and the percent reduction required for all watershed sources are presented in **Table 8-1**.

Table 8-1: TMDL Load Allocation for the South Run

Source	Land Use Type	Impaired Watershed (ton/year)	Reduction (%)
Land Sources	Deciduous Forest	0.000	0
	Evergreen Forest	0.000	0
	Mixed Forest	0.000	0
	Pasture/Hay/Livestock	0.209	0
	Row Crop	0.044	0
	Low intensity residential	0.099	0
	Commercial/Industrial	0.044	0
	Medium/High Residential	0.000	0
	Institutional	0.000	0
	Urban/Recreational Grass	0.000	0
	Groundwater	0.088	0
	Septic System	0.011	0
Point Sources		0.010	94
Total		**0.5058**	-

8.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Chesapeake Bay. Several BMPs known to be effective in controlling phosphorus have also been identified for implementation as part of the Tributary Strategy for the Potomac River basin. Since phosphorus can be dissolved or in adsorbed to particulate matter, mainly sediment, control measures to reduce the sediment load will directly impact and reduce the phosphorus loading to the receiving stream. Examples of sediment and nutrient pollution reduction practices include:

- Agricultural Best Management Practices (BMP) includes practices to reduce or eliminate soil loss, prevent runoff, and provide for the proper application rates of nutrients to cropland, vegetated buffer strips at the edge of crop fields, conservation tillage, strip cropping, animal waste management, and stream bank fencing
- Urban Best Management Practices which include erosion and sediment BMPs to control runoff from areas under development and stormwater controls in developed areas. These practices are applied across a broad spectrum from industrial, commercial, and residential facility construction sites to the management of lawns and open spaces, reducing nutrient runoff.
- Stormwater Management controls including Low Impact Development (LID)

- Upgrades made to wastewater treatment plants, many which are preformed during the installation of bioloigcal nutrient removal (BNR) process to meet Bay nutrient allocations.
- Septic system maintenance
- Stream Buffers. Streamside forest to reduce or remove excess nutrients and sediment from surface runoff and shallow groundwater and aid in shading streams to optimize light and temperature conditions for aquatic plants and animals.

8.4 Reasonable Assurance for Implementation

8.4.1 Follow-Up Monitoring

Following the development of the TMDL, the Department of Environmental Quality (DEQ) will make every effort to continue to monitor the impaired stream in accordance with its ambient and biological monitoring programs. DEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. In accordance with DEQ Guidance Memo No. 03-2004, during periods of reduced resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. Monitoring can resume at the start of the following fiscal year, next scheduled monitoring station rotation, or where deemed necessary by the regional office or TMDL staff, as a new special study. Since there may be a lag time of one-to-several years before any improvement in the benthic community will be evident, follow-up biological monitoring may not have to occur in the fiscal year immediately following the implementation of control measures.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year.

DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the IP), the effectiveness of the TMDL in attaining and maintaining water quality standards, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by citizens' or watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with DEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or Implementation plan has been completed), DEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

8.4.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. EPA also requires that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). All such permits should be submitted to EPA for review.

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL's LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed. An exception are the municipal separate storm sewer systems (MS4s) which are both covered by NPDES permits and expected to be included in TMDL implementation plans, as described in the stormwater permit section below.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the state's Water Quality Management Plans. The WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as is the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf

8.4.3 Stormwater Permits

DEQ and DCR coordinate separate State programs that regulate the management of pollutants carried by storm water runoff. DEQ regulates storm water discharges associated with "industrial activities", while DCR regulates storm water discharges from construction sites, and from municipal separate storm sewer systems (MS4s).

EPA approved DCR's VPDES storm water program on December 30, 2004. DCR's regulations became effective on January 29, 2005. DEQ is no longer the regulatory agency responsible for administration and enforcement of the VPDES MS4 and construction storm water permitting programs. More information is available on DCR's web site through the following link: http://www.dcr.virginia.gov/sw/vsmp

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is DCR's Virginia Stormwater Management Program (VSMP) Permit Regulation (4 VAC 50-60-10 et. seq). Section 4VAC 50-60-380 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that NPDES permit conditions may consist of "Best management practices to control or abate the discharge of pollutants when:…(2) Numeric effluent limitations are infeasible,…".

Part of the South Run watershed is covered by a permit for a small municipal separate storm sewer system (MS4s) owned by the City of Warrenton. The permit states, under Part II.A., that the "permittee must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law."

The permit also contains a TMDL clause that states: "If a TMDL is approved for any waterbody into which the small MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of stormwater discharges. If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Stormwater Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." ("Board" means the Soil and Water Conservation Board)

For MS4/VSMP general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations for stormwater through the implementation of programmatic BMPs. BMP effectiveness would be determined through ambient in-stream monitoring. This is in accordance with recent EPA guidance (EPA Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002). If future monitoring indicates no improvement in stream water quality, the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation. However, only failing to implement the programmatic BMPs identified in the modified stormwater management program would be considered a violation of the permit. Any changes to the TMDL resulting from water quality standards changes on South Run would be reflected in the permit.

Wasteload allocations for stormwater discharges from storm sewer systems covered by a MS4 permit will be addressed in TMDL implementation plans. An implementation plan will identify types of corrective actions and strategies to obtain the wasteload allocation for the pollutant causing the water quality impairment. Permittees need to participate in the development of TMDL implementation plans since recommendations from the process may result in modifications to the stormwater management plan in order to meet the TMDL.

Additional information on Virginia's Stormwater Phase 2 program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/sw/vsmp.htm .

8.4.4 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

8.4.5 Attainability of Designated Uses

In some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use.

In order for a stream to be assigned a new designated use, the current designated use must be removed. To remove a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of the contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/WQS03AUG.pdf

The process to address potentially unattainable reductions based on the above is as follows: First is the development of a stage 1 scenario such as those presented previously in this chapter. The pollutant reductions in the stage 1 scenario are targeted only at the controllable, anthropogenic sources identified in the TMDL. During the implementation of the stage 1 scenario, all controllable sources would be reduced to the maximum extent practicable using the iterative approach described in Section 8.2 above. DEQ will re-assess water quality in the stream during and subsequent to the implementation of the stage 1 scenario to determine if the water quality standard is attained. This effort will also evaluate if the modeling assumptions were correct. If water quality standards are not being met, and no additional cost-effective and reasonable best management practices can be identified, a UAA may be initiated with the goal of re-designating the stream for a more appropriate use.

9.0 Public Participation

The development of the South Run benthic TMDL would not have been possible without public participation. Three technical advisory committee (TAC) meetings and three public meetings were held. The following is a summary of the meetings.

TAC Meeting No. 1. The first TAC meeting was held on March 1, 2005 at the DEQ office in Woodbridge to present and review the steps and the data used in the development of the benthic TMDLs for the South Run listed segment.

TAC Meeting No. 2. The second TAC meeting was held on November 3, 2005 at the DEQ office in Woodbridge, VA to discuss the preliminary benthic stressors identified for South Run.

TAC Meeting No. 3. The third TAC meeting was held on March 1, 2006 at the DEQ office in Woodbridge VA to discuss the completed TMDL for South Run benthic impairment.

Public Meeting No. 1. The first public meetings were held in on March 30, 2005 at the Sully District Governmental Center in Chantilly, Virginia and on April 5, 2005 at the Pennington School in Manassas, Virginia to present the process for TMDL development, the South Run benthic impaired segment, data that caused the segment to be on the 303(d) list, data and information needed for TMDL development, and preliminary findings regarding potential stressors. Nineteen people added these meetings. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register*. No written comments were received during the 30-day comment period.

Public Meeting No. 2. The second public meeting was held in on December 14, 2005 at the Sully District Governmental Center in Chantilly, Virginia to discuss the preliminary benthic stressors identified for South Run. Six people attended this meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

Public Meeting No. 3. The third public meeting on the development of the Occoquan Basin Streams TMDLs was held on March 15, 2006 at the. Central Community Library in Manassas, VA to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft TMDL. Ten people attended this meeting.Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

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